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ESE 2021

Preliminary Examination

Detailed Solutions of Electrical Engineering

Set-A

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Expected Cutoff of ESE 2021 Prelims Exam (Out of 500 Marks)				
Branch	Gen	OBC	SC	ST
CE	260-270	250-260	220-230	220-230
ME	280-290	270-280	230-240	220-230
EE	250-260	240-250	210-220	200-210
E&T	270-280	260-270	220-230	210-220

Actual Cutoff of ESE 2020 Prelims Exam (Out of 500 Marks)				
Branch	Gen	OBC	SC	ST
CE	238	238	202	227
ME	262	250	214	202
EE	238	229	187	194
E&T	245	245	205	202

Electrical Engineering Paper Analysis of ESE 2021 Prelims Exam

Sl.	Subjects	Number of Questions
1	Engineering Mathematics	14
2	Electrical Materials	14
3	Electric Circuits	11
4	Signals and Systems	9
5	Power Systems	11
6	Measurements	13
7	Computer Fundamentals	4
8	Digital Electronics	3
9	Microprocessor	6
10	Analog Electronics	13
11	Communication Systems	9
12	Control Systems	13
13	Electrical Machines	18
14	Power Electronics	8
15	Electromagnetic Theory	4

UPSC ESE/IES Prelims 2021
EE analysis and expected cutoff

by **MADE EASY faculties**

https://www.youtube.com/watch?v=edHc66b9WzQ

1. A point charge of 10^{-9} C is placed at a point *A* in free space. What is the intensity of electrostatic field on the surface of a sphere of radius 5 cm at centre *A*?

(Take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ in SI units)

(a) 1800 V/m
(b) 3600 V/m
(c) 5360 V/m
(d) 2820 V/m

Ans. (b)

$$Q = 10^{-9}\ \text{C}$$

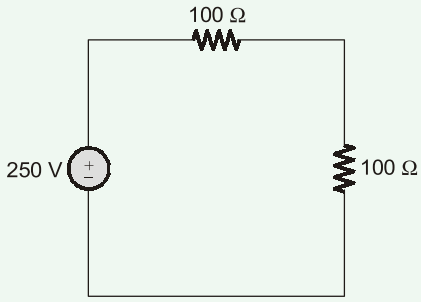
$$E = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{10^{-9} \times 9 \times 10^9}{(5 \times 10^{-2})^2} = 3600\ \text{V/m}$$

End of Solution

2. A generator develops 250 V and has an internal resistance of 100 ohm. If the load resistance is 100 ohm, then what is the efficiency of the generator?

(a) 80%
(b) 50%
(c) 60%
(d) 70%

Ans. (b)



$$I = \frac{250}{200} = \frac{5}{4}$$

$$P_L = \left(\frac{5}{4}\right)^2 \times 100$$

$$P_S = \left(\frac{5}{4}\right) \times 250$$

$$\eta = \frac{P_L}{P_S} \times 100$$

$$\eta = 50\%$$

or Load resistance = Source resistance

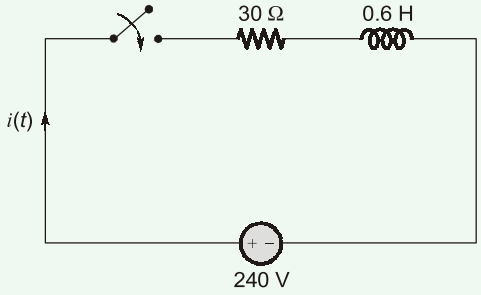
$$\eta = 50\%$$

End of Solution

3. A coil resistance 30 Ω and inductance 0.6 H is switched on to a 240 V supply. What are the rate of change of current at the instant of closing the switch at $t = 0$ and the magnitude of the final steady state current respectively?

(a) 80 A/sec and 80 A
(b) 400 A/sec and 8 A
(c) 8 A/sec and 80 A
(d) 400 A/sec and 80 A

Ans. (b)



$$240 = 30i(t) + 0.6\frac{di(t)}{dt}$$

$t = 0^+$, $\quad i(0^+) = 0$ A

$$240 = 30i(0^+) + 0.6\frac{di(0^+)}{dt}$$

$$\frac{di(0^+)}{dt} = \frac{240}{0.6} \Rightarrow 400 \text{ A/s}$$

At steady state inductor acts as a short circuit.

$$i(\infty) = \frac{V}{R} = \frac{240}{30} = 8 \text{ A}$$

End of Solution

4. A current of 10 A flows in a circuit with a 30° angle of lag when the applied voltage is 100 V. What are the values of resistance and reactance in the circuit respectively?

(a) 8.66 Ω and 5 Ω
(b) 5 Ω and 8.66 Ω
(c) 6.66 Ω and 4 Ω
(d) 4 Ω and 6.66 Ω

Ans. (a)

$$I = 10\angle -30°$$
$$V = 100 \text{ V}$$
$$Z = \frac{V}{I} = \frac{100}{10\angle -30°} = 10\angle 30°$$
$$Z = 10\cos 30° + j10 \sin 30°$$
$$Z = (8.66 + j5)\ \Omega$$

End of Solution

5. Consider the following statements regarding reciprocity theorem :

1. In any passive linear bilateral network, if the single voltage source V_x in branch x produces the current response I_y in branch y, then the removal of the voltage source from branch x and its insertion in branch y will produce the current response I_y in branch x.
2. The interchange of an ideal voltage source and an ideal ammeter in any passive, linear, bilateral circuit will not change the ammeter reading.
3. The interchange of an ideal current source and an ideal voltmeter in any passive linear bilateral circuit will change the voltmeter reading.

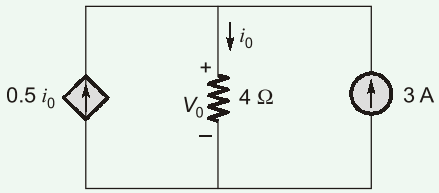
Which of the above statements are correct?

(a) 1 and 3 only
(b) 1 and 2 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. (b)

End of Solution

6. What is the value of V_o in the given circuit?



(a) 12 V
(b) 6 V
(c) 24 V
(d) 15 V

Ans. (c)

Apply KCL,

$$3 + 0.5i_o = i_o$$
$$i_o = 6 \text{ A}$$
$$V_o = 6 \times 4 = 24 \text{ V}$$

i_o

End of Solution

7. A network has 8 branches and 4 independent loops. How many nodes are there in the network?

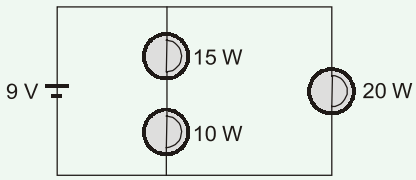
(a) 11
(b) 13
(c) 5
(d) 3

Ans. (c)

$$\text{No. of links } (l) = b - n + 1$$
$$l = b - n + 1$$
$$4 = 8 - n + 1$$
$$n = 5$$

End of Solution

8. Three light bulbs are connected to a 9 V battery as shown in the figure. What are the values of the resistance of 20 W, 15 W, 10 W bulbs respectively?



(a) 4.05 Ω, 1.945 Ω, 1.297 Ω
(b) 6.02 Ω, 3.762 Ω, 3.162 Ω
(c) 7.672 Ω, 4.887 Ω, 4.223 Ω
(d) 8.345 Ω, 6.893 Ω, 5.634 Ω

Ans. (a)

$$P_{20} = \frac{V^2}{R_{20}}$$

$$R_{20} = \frac{9 \times 9}{20} = 4.05\ \Omega$$

Power of first branch

$$P = 10 + 15 = 25\ \text{W}$$

Total resistance of first branch

$$R = \frac{9 \times 9}{25} = 3.24\ \Omega$$

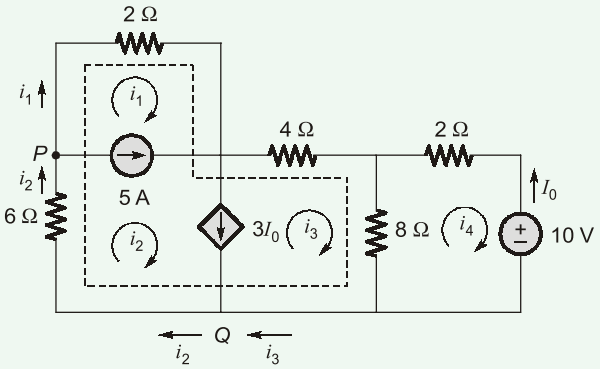
Current through first branch,

$$I = \frac{9}{3.24} \Rightarrow 2.777\ \text{A}$$

$$P_{15w} = I^2 R_{15}$$
$$R_{15} = 1.945\ \Omega$$
$$P_{10} = I^2 R_{10}$$
$$R_{10} = 1.297\ \Omega$$

End of Solution

9. For the circuit in figure, the values of i_1 and i_4 are respectively,



(a) –7.5 A, 2.143 A
(b) –2.5 A, 3.93 A
(c) 3.4 A, –6.5 A
(d) 7.1 A, –3.4 A

Ans. (a)

Write KVL in 4th loop

$$10i_4 - 8i_3 = -10 \quad \ldots(1)$$

Substitute $i_4 = -I_o$ in eq. (1)

$$10I_o + 8i_3 = 10$$

$$I_o = 1 - 0.8i_3$$

Write KVL equation for 3 loops at a time

$$2i_1 + 6i_2 + 12i_3 - 8i_4 = 0$$

$$i_4 = -I_0$$

$$2i_1 + 6i_2 + 12i_3 + 8I_0 = 0 \quad \ldots(2)$$

Substitute I_o value in eqn. (2)

$$2i_1 + 6i_2 + 5.6i_3 = -8 \quad \ldots(3)$$

$$i_2 - i_1 = 5 \quad \ldots(4)$$

$$i_2 - i_3 = 3I_0 \quad \ldots(5)$$

Sub. I_0 value in eq. (5)

$$i_2 - i_3 = 3(1 - 0.8i_3)$$

$$i_2 + 1.4i_3 = 3 \quad \ldots(6)$$

Solve eq. (3), (4) and (6),

$$i_1 = -7.5 \text{ A},$$

$$i_3 = 3.928 \text{ A}$$

$$I_0 = -2.143 \text{ A}$$

$$\therefore \quad i_4 = 2.143 \text{ A}$$

End of Solution

10. An energy source forces a constant current of 2 A for 10 s to flow through a light bulb. If 2.3 kJ is given off in the form of light and heat energy, what is the voltage drop across the bulb?

(a) 120 V (b) 115 V

(c) 110 V (d) 105 V

Ans. (b)

$$H = I^2Rt$$

$$2.3 \times 10^3 = 2^2 \times R \times 10$$

$$R = 57.5\ \Omega$$

$$V = IR$$

$$V = 115 \text{ V}$$

End of Solution

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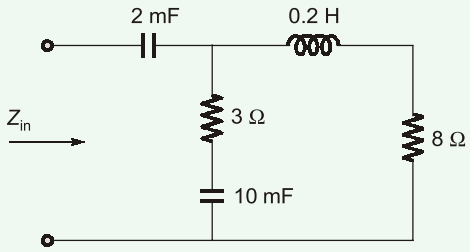
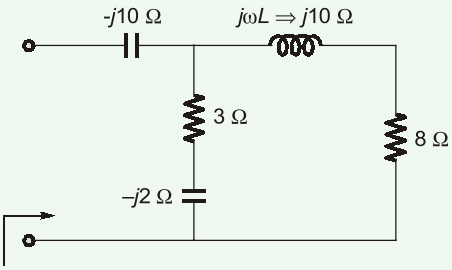
11. What is the input impedance of the circuit, if the circuit operates at $\omega = 50$ rad/s?



(a) $(5.63 - j5.94)\Omega$
(b) $(3.22 - j11.07)\Omega$
(c) $(4.54 + j6.79)\Omega$
(d) $(6.86 + j13.54)\Omega$

Ans. (b)



$$Z_{in} = \frac{(8+j10)(3-j2)}{8+j10+3-j2} - j10$$

$$= (3.22 - j11.07)\ \Omega$$

End of Solution

12. A three-phase motor can be regarded as a balanced Y-load. A three-phase motor draws 5.6 kW, when the line voltage is 220 V and the line current is 18.2 A. What is the power factor of the motor?

(a) 0.8075
(b) 0.6134
(c) 0.9593
(d) 0.7947

Ans. (a)

$$\sqrt{3}V_L I_L \cos\phi = 5600$$

$$\cos\phi = \frac{5600}{\sqrt{3}\times 220\times 18.2} = 0.8075$$

End of Solution

13. A 0-150 V voltmeter has a guaranteed accuracy of 1% of full scale reading. The voltage measured by this instrument is 75 V. What is the percentage of limiting error?

(a) 1% (b) 2%

(c) 3% (d) 4%

Ans. **(b)**

$$\% \in_r \text{ at } 75 \text{ V} = \frac{150 \times 1}{75} = 2\%$$

End of Solution

14. What is the value of shunt resistance of an ammeter, if the range is extended from 1 mA to 10 mA and metre has a resistance of 27 Ω?

(a) 3 Ω (b) 4 Ω

(c) 2.5 Ω (d) 3.5 Ω

Ans. **(a)**

$$R_{sh} = \frac{R_m}{(m-1)} = \frac{R_m}{\left(\frac{I}{I_m} - 1\right)} = \frac{27}{\left(\frac{10}{1} - 1\right)} = 3\ \Omega$$

End of Solution

15. In a dynamometer type wattmeter at low power factor, the inductance of the pressure coil introduces a serious error. This error can be minimized by

(a) connecting a high resistance in series with it and connecting a capacitor across a part of this resistance.

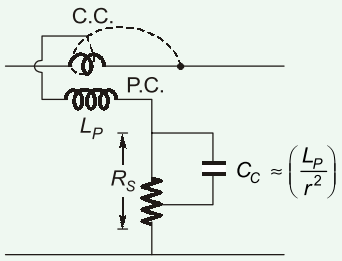
(b) connecting a high resistance in parallel with it and connecting a capacitor across a part of this resistance.

(c) connecting a low resistance in series with it and connecting a capacitor across a part of this resistance.

(d) connecting a low resistance in parallel with it and connecting a capacitor across a part of this resistance.

Ans. **(a)**

LPF wattmeter :



Connecting a capacitor (compensating capacitor) parallel to some part of high resistance (R_s) which is in series with potential coil.

End of Solution

16. Which one of the following instruments is the most sensitive of the moving iron mechanism and has the most linear scale?

(a) Moving coil
(b) Hot wire
(c) Electrodynamometer
(d) Radial vane repulsion

Ans. **(d)**

Repulsion instruments are more suitable for economical production in manufacture, and a nearly uniform scale is more easily obtained. Out of the other moving iron mechanism, radial vane repulsion is the most sensitive and has most linear scale.

End of Solution

17. A voltmeter has a resistance of 300 Ω and inductance of 0.12 H. This instrument reads correctly on DC. What is the reading on AC at 100 V when the frequency is 25 Hz?

(a) 99.80 V
(b) 120.36 V
(c) 142.00 V
(d) 151.00 V

Ans. **(a)**

For DC measures correctly

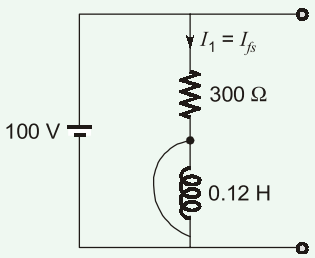
$$I_1 = I_{fs} = \frac{100\,\text{V}}{300\,\Omega} = \frac{1}{3} = 0.333\,\text{A}$$

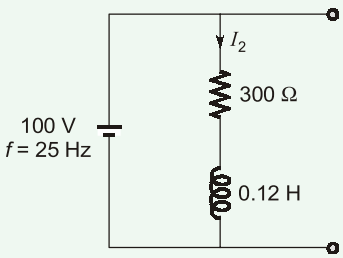
For AC of 100 V, $f = 25$ Hz

$$I_2 = \frac{100}{\sqrt{(300)^2 + (2\pi \times 25 \times 0.12)^2}}$$

$$= \frac{100}{300.59} \Rightarrow 0.3326 \text{ A}$$

DC





DC : 0.3333 A → 100 V

For AC current of 0.3326 A → ?

$$\text{Reading} = \frac{100}{0.3333} \times 0.3326 = 99.8 \text{ V}$$

End of Solution

18. A voltmeter has a resistance of 20 kΩ and connected in series with an external resistance across a 230 V supply. If the instrument reads 160 V, then the value of external resistance is

(a) 6745 Ω (b) 7748 Ω
(c) 8750 Ω (d) 9752 Ω

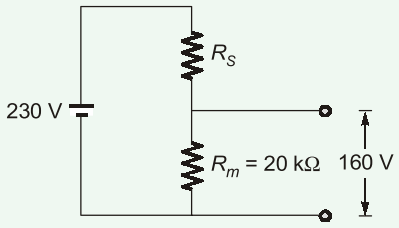
Ans. (c)

$V_m = 160\ \text{V}$
$R_m = 20\ \text{k}\Omega$
$V = 230\ \text{V}$
$R_s = R_m(m-1)$

$= R_m\left(\frac{V}{V_m} - 1\right)$

$= 20\times10^3\left(\frac{230}{160} - 1\right)$

$= 8.75\ \text{k}\Omega = 8750\ \Omega$



End of Solution

19. A moving coil instrument gives full-scale deflection with 15 mA and has a resistance of 5 Ω. The value of resistance to be connected in series to enable it to read up to 100 V is

(a) 6666.66 Ω (b) 6660.66 Ω
(c) 6661.60 Ω (d) 6662.60 Ω

Ans. (c)

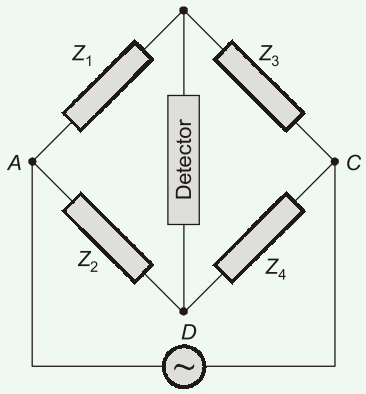
$V_m = R_m \times I_n = 15 \times 5 = 75\ \text{mV}$
$V = 100\ \text{V}$

$R_s = R_m\left(\frac{V}{V_m} - 1\right) = 5\left(\frac{100}{75\times10^{-3}} - 1\right) = 6661.66\ \Omega$

End of Solution

20. The impedances of an AC bridge as shown in figure below are as follows :

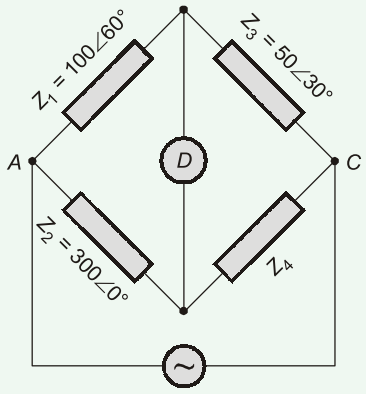
Z_1 = 100 Ω with phase angle of 60°, Z_2 = 300 Ω with phase angle of 0°, and Z_3 = 50 Ω with phase angle of 30°. What is the nature of unknown impedance Z_4?



(a) Purely resistive circuit
(b) Series R-C circuit
(c) Series R-L circuit
(d) Parallel R-L circuit

Ans. **(b)**

At balance,



$$Z_1Z_4 = Z_2Z_3$$

$$Z_4 = \frac{Z_2Z_3}{Z_1} = \frac{300 \times 50\angle 30°}{100\angle 60°}$$

$$= 150\angle -30°$$

$$= 150\cos 30° - j150\sin 30°$$

$$= R - jX_C = (130 - j75)\ \Omega$$

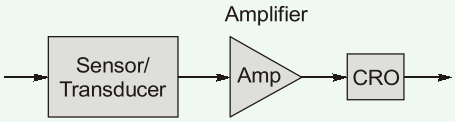
Z_4 contains R and C.

End of Solution

21. Consider a measuring system consisting of a sensor, an amplifier and an oscilloscope. The sensitivity of each equipment is as follows : Sensor sensitivity : 0.4 mV/°C, Amplifier gain : 5.0 V/mV, and Oscilloscope sensitivity : 10 mV/V. What is the sensitivity of complete measurement system?

(a) 5.0 V/mV
(b) 10 mV/V
(c) 15.4 mV/°C
(d) 20 mV/°C

Ans. (d)



$S_1 = 0.4$ mV/° C
$S_2 = 5$ V/mV
$S_3 = 10$ mV/V
Overall sensitivity $= S_1 \times S_2 \times S_3$
$= 0.4 \times 5 \times 10 = 20$ mV/° C

End of Solution

22. A moving coil meter of 50 Ω resistance reads up to 25 mA. What is the value of series resistance, so that it can be read upto 10 V?

(a) 300 Ω
(b) 250 Ω
(c) 350 Ω
(d) 400 Ω

Ans. (c)

$I_{fs} = 25$ mA $= I_m$
$R_m = 50\ \Omega$
$V_m = I_m \cdot R_m = 1.25$ V
$R_S = R_m (m - 1)$
$= R_m\left(\frac{V}{V_m} - 1\right) = 50\left(\frac{10}{1.25} - 1\right) = 350\ \Omega$

End of Solution

23. Which one of the following analog to digital conversion methods is called potentiometric type analog to digital converter?

(a) Successive approximation method
(b) Voltage to time conversion method
(c) Voltage to frequency conversion method
(d) Dual slope integration method

Ans. (a)

Potentiometric A/D converter:

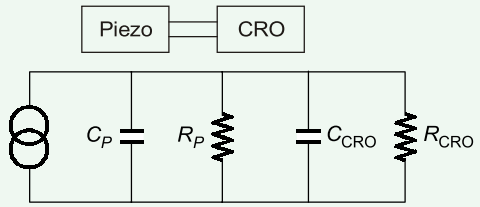
The potentiometric A/D converter is probably the most widely used in general practice on account of its high resolution and high speed. The potentiometric type A/D converter works on the principle of successive approximation.

End of Solution

24. A piezoelectric transducer has a capacitance of 1500 pF and leakage resistance of 10^5 MΩ. The oscilloscope used for read-out has a resistance of 1 MΩ in parallel with a capacitance of 500 pF. What is the time constant of the entire system?

(a) 0.002 s
(b) 0.20 s
(c) 20 s
(d) 200 s

Ans. (a)



$C_p = 1500$ pF, $C_{CRO} = 500$ pF
$R_p = 10^5$ MΩ, $R_{CRO} = 1$ MΩ
$C_T = C_P + C_{CRO} = 1500 + 500 = 2000$ pF
$R_T = R_p \,||\, R_{CRO} = 1\ M\Omega \,||\, 10^5$ MΩ
$= 1$ MΩ
Time constant $= R_T \times C_T$
$= 2000 \times 10^{-12} \times 1 \times 10^6$
$= 2$ msec $= 0.002$ sec

End of Solution

25. Consider the following regarding the drawbacks of BCD arithmetic over binary arithmetic:

1. Perform arithmetic operations indirectly on decimal data.
2. Take more time for execution.
3. Less efficient use of memory.
4. Small number of computations are required

which of the above drawbacks are correct?

(a) 1 and 4 only
(b) 2 and 3 only
(c) 1, 2 and 3 only
(d) 1, 2, 3 and 4

Ans. (b)

End of Solution

26. Which one of the following registers holds the data on which the system has to operate, intermediate results and results of operations performed?

(a) Program control register
(b) Accumulator register
(c) Instruction register
(d) Input/output register

Ans. (b)

Accumulator contains one of the operand in most of the ALU operations and result is also stored in accumulator.

End of Solution

27. Which one of the following is NOT a general operation of machine cycle in a central processing unit?

(a) Fetch (b) Decode
(c) Return (d) Store

Ans. **(c)**

Basic operations are Fetch, Read and Write/Store. return is an instruction used in a subroutine in order to return to the main program.

End of Solution

28. Consider the following statements in order perform a write operation into a specific memory location, the MDR and MAR :

1. The word to be stored into the memory location is first loaded by CPU in MDR.
2. The address of the location into which the word is to be stored is loaded by the CPU into MAR.
3. A write signal is issued by the CPU.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Operand store microprogram is,

T_1 : ACC (Data) $\rightarrow$ MDR

T_2 : IR[Addr] $\rightarrow$ MAR

T_3 : MDR $\rightarrow$ $\underbrace{\text{M[MAR]}}_{\text{Memory}}$

End of Solution

29. In which one of the following modes does the DMA controller keep control of the bus units all the data has been transferred to (from) memory from (to) the peripheral device?

(a) Burst mode (b) Transfer mode
(c) Mice mode (d) Addressing mode

Ans. **(a)**

Direct memory access is used to transfer huge amount of data from memory to output deivce or input device to memory.

Depending on availability of microprocessor and number of devices, the modes are Burst mode, cycle stealing technique and interleaved DMA.

End of Solution

30. Which one of the following addressing mode leads to poor programming practice?

(a) Direct addressing mode (b) Indirect addressing mode
(c) Immediate addressing mode (d) Implied addressing mode

Ans. **(a)**

Direct addressing mode: as program length increases and more memory space is required

Number of machine cycles are also more, so it is more time consuming.

End of Solution

31. Consider the following statements for a simple assembler :

1. It scans the entire assembly program twice, where each scan is called a pass.
2. It generates a table that includes all symbols and their binary values.
3. It will use the symbol table and other tables to generate the object program and output some information that will be needed by the linker.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

All are true.

End of Solution

32. Daisy-chaining method is used for

(a) establishing priority (b) data transfer
(c) initiating input and ouput (d) direct memory access

Ans. **(a)**

Daisy-chaining method is used for establishing priority consists of a serial connection of all devices that request an interrupt. The device with the high priority is placed in the first position followed by lower priority devices.

End of Solution

33. The performance of cache memory is measured in terms of

(a) Read ratio (b) Reference ratio
(c) Hit ratio (d) Locality ratio

Ans. **(c)**

$$\text{Hit Ratio (H)} = \frac{\#\text{ Hits}}{\text{Total }\#\text{ Accesses}}$$

End of Solution

34. According to the Belady's anomaly, the page-fault rate may
(a) increase as the number of allocated frames increases.
(b) increase as the number of allocated frames decreases.
(c) not change as the number of allocated frames increases.
(d) not change as the number of allocated frames decreases.

Ans. **(a)**
Belady's anomaly is that page fault rate may increases as the number of allocated frames increases.

End of Solution

35. What is the maximum bit rate of a noiseless channel with a bandwidth of 1000 Hz transmitting a signal with two signal levels?
(a) 2000 bps (b) 3000 bps
(c) 4000 bps (d) 6000 bps

Ans. **(a)**
For noiseless channel Nyquist bit rate formula defines the theoretical maximum bit rate.
If the signal consists of L discrete level, Nyquist theorem states that maximum bit rate
$= 2 \times \text{bandwidth} \times \log_2 L$
$\text{Maximum bit rate} = 2 \times 1000 \times \log_2 2$
$= 2000 \text{ bps}$

End of Solution

36. A signal has eight data levels with a pulse duration of 1 ms. What is the bit rate?
(a) 1000 bps (b) 2000 bps
(c) 3000 bps (d) 4000 bps

Ans. **(c)**
Signal has 8 levels, i.e., $M = 8$
Pulse duration (or) symbol duration = 1 ms

$$\text{Symbol rate} = \frac{1}{1\text{ ms}} = 1000 \text{ symbols/sec}$$

$$\text{Symbol rate} = \frac{\text{Bit rate}}{\log_2 M}$$

$$\text{Bit rate} = 1000 \times \log_2 8$$
$$= 3000 \text{ bps}$$

End of Solution

37. In a CB configuration, the current amplification factor is 0.97. If the emitter current is 1 mA, the value of base current is
(a) 0.97 mA (b) 1.0 mA
(c) 0.03 mA (d) 1.03 mA

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Ans. (c)

$$\alpha = 0.97$$
$$I_E = 1 \text{ mA}$$
$$I_B = ?$$
$$I_E = (1 + \beta)I_B$$
$$= \frac{1}{1-\alpha} \times I_B$$
$$I_B = (1 - \alpha)I_E$$
$$= 0.03 \times 1 \text{ mA}$$
$$= 0.03 \text{ mA}$$

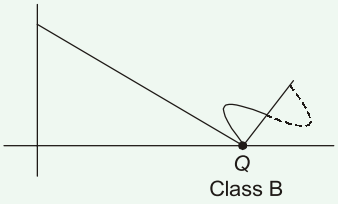
End of Solution

38. The power amplifiers in which the operating point is so adjusted that the collector current flows only during the positive half-cycle of the input signal are known as

(a) Class-B amplifiers
(b) Class-A amplifiers
(c) Class-AB amplifiers
(d) Class-C amplifiers

Ans. (a)

Power amplifier in which operating point is so adjusted that collector current flows only during positive half cycle is class B amplifiers.



End of Solution

39. A multistage amplifier employs four stages, each of which has a voltage gain of 40. The overall gain of the amplifier is approximately

(a) 32 dB
(b) 64 dB
(c) 96 dB
(d) 128 dB

Ans. (d)

A multistage amplifier has four stages. Each has voltage gain 40.

$$\text{Overall gain} = 40 \times 40 \times 40 \times 40$$
$$= 256 \times 10^4$$
$$A_v|_{dB} = 20 \log(256 \times 10^4)$$
$$= 20 \log 256 + 20 \log 10^4$$
$$= 20 \log 256 + 80$$
$$= 48.16 + 80 \simeq 128 \text{ dB}$$

End of Solution

40. Consider the following statements regarding R-C coupled amplifiers :

1. The cost of R-C coupled amplifier is low because of low cost of coupling capacitors and resistors.
2. They occupy less space because of small size of resistors and capacitors.
3. They have better frequency response.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1, 2 and 3 only (d) 1 and 3 only

Ans. (d)

RC Coupled Amplifier :

1. The cost of RC coupled amplifier is low because of low cost of coupling capacitors and resistors.
2. They have better frequency response.

End of Solution

41. For depletion type MOSFET : I_D = 4.5 mA at V_{GS} = –2 V. What is the value of I_{DSS} if V_P = –5 V?

(a) 5.5 mA (b) 12.5 mA
(c) 5.0 mA (d) 15 mA

Ans. (b)

Depletion MOSFET :

$$I_D = 4.5 \text{ mA at } V_{GS} = -2 \text{ V}$$
$$I_{DSS} = ?$$
$$V_P = -5 \text{ V}$$

$$I_D = I_{DSS}\left[1-\frac{V_{GS}}{V_P}\right]^2$$

$$4.5 \text{ mA} = I_{DSS}\left[1-\frac{-2}{-5}\right]^2$$

$$= I_{DSS}\left[1-\frac{2}{5}\right]^2$$

$$4.5 \text{ mA} = I_{DSS}\left[\frac{5-2}{5}\right]^2$$

$$4.5 \text{ mA} = I_{DSS}\left[\frac{3}{5}\right]^2$$

$$I_{DSS} = \frac{4.5 \text{ mA} \times 25}{9}$$
$$= 12.5 \text{ mA}$$

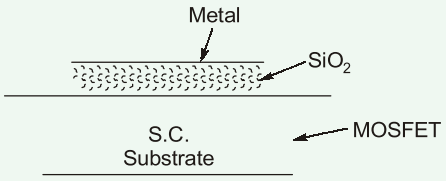
End of Solution

42. Which one of the following consists of a layer of metal at the top named gate, a silicon dioxide layer below it, and a semiconductor substrate as the bottom-most layer?

(a) JFET (b) BJT

(c) MOSFET (d) DMOSFET

Ans. (c)



End of Solution

43. In a common base configuration, the alpha of the transistor is 0.99, its collector current is 1 mA and the collector to base current with emitter open is 1 μA. The value of base current is

(a) 29 μA (b) 19 μA

(c) 9 μA (d) 39 μA

Ans. (c)

$$\alpha = 0.99$$
$$I_C = 1\ \text{mA}$$
$$I_{CBO} = 1\ \mu\text{A}$$
$$I_B = ?$$
$$I_C = \beta I_B + (1 + \beta) I_{CBO}$$
$$I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}$$
$$1\ \text{mA} = \frac{0.99}{1-0.99} I_B + \frac{1}{1-0.99} \times 1\ \mu\text{A}$$
$$1\ \text{mA} = 99 I_B + 100 \times 1\ \mu\text{A}$$
$$= 99 I_B + 0.1\ \text{mA}$$
$$1\ \text{mA} - 0.1\ \text{mA} = 99 I_B$$
$$99 I_B = 0.9\ \text{mA}$$
$$I_B = \frac{0.9\ \text{mA}}{99}$$
$$= 9.09\ \mu\text{A}$$

End of Solution

44. The MOSFET is in the cut-off state, when the gate source voltage is

(a) less than gate to source voltage (b) greater than gate to source voltage

(c) less than the threshold voltage (d) greater than the threshold voltage

Ans. (c)

MOSFET is in cut-off state.

$$V_{GS} < V_t$$

End of Solution

45. For an ideal power supply, the output voltage is independent of the load and the percentage regulation is

(a) equal to zero.
(b) equal to unity.
(c) greater than unity.
(d) less than unity but not zero.

Ans. (a)

Output voltage is independent of load

% VR will be zero.

End of Solution

46. For an n-channel silicon FET with $a = 3 \times 10^{-4}$ cm and $N_D = 10^{15}$ electron/cm^3, what is the pinch-off voltage if the dielectric constant of silicon is $\varepsilon = 12\varepsilon_0$ and $\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9}$?

(a) 6.8 V
(b) 5.2 V
(c) 8.8 V
(d) 9.2 V

Ans. (a)

n-channel Si FET

$$a = 3 \times 10^{-4} \text{ cm}$$
$$N_D = 10^{15} \text{ electron/cm}^3$$
$$V_p = ?$$
$$\varepsilon = 12\varepsilon_0$$

where $\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9}$ F/m

$= 8.85 \times 10^{-12}$ F/m or 8.85×10^{-14} F/cm

$$V_p = \frac{a^2 q N_D}{2\epsilon}$$

$$V_p = \frac{(3\times10^{-4})^2 \times 1.6\times10^{-19} \times 10^{15}}{2\times12\times8.85\times10^{-14}}$$

$= 6.8$ V

End of Solution

47. What is the output voltage for an integrator when input is a step voltage for $0 \le t \le 2$, $R_1C_F = 3$ sec and $V_{in} = 6$ V?

(a) –4 V
(b) –6 V
(c) –8 V
(d) –10 V

Ans. (a)

$$V_o = -\frac{1}{RC}\int V_i dt$$

$$= \frac{-1}{3\ \text{sec}}\int_0^2 6dt$$

$$= -\frac{6}{3}[t]_0^2$$

$$= -\frac{6}{3}\times 2$$

$$= -\frac{12}{3} = -4$$

$$= -4\ \text{V}$$

End of Solution

48. Consider the following statements related to Hall effect :

1. Hall effect is used to determine whether a semiconductor is *n*-type or *p*-type.
2. To find the carrier concentration.
3. Measuring the conductivity (σ), the mobility (μ) can be calculated.
4. The Hall effect has been incorporated into a magnetic field meter.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2, 3 and 4 only
(c) 1, 3 and 4 only
(d) 1, 2, 3 and 4

Ans. (d)

End of Solution

49. The residue at the singular point $z = -2$ of $f(z) = \dfrac{1+z+z^2}{(z-1)^2(z+2)}$ is

(a) $\frac{1}{2}$
(b) $\frac{1}{3}$
(c) $\frac{4}{3}$
(d) $\frac{3}{2}$

Ans. (b)

$$\underset{z=-2}{\text{Res}} = \lim_{z\to -2}\times (z+2)\frac{1+z+z^2}{(z-1)^2(z+2)}$$

$$\Rightarrow \quad \frac{1-2+4}{(-3)^2} = \frac{5-2}{9} = \frac{1}{3}$$

End of Solution

50. The solution of the differential equation $(1 + e^{x/y}) + e^{x/y}\left(1-\frac{x}{y}\right)\frac{dy}{dx} = 0$ is

(a) $x + ye^{x/y} = C$ (b) $y + xe^{x/y} = C$

(c) $1 + e^{x/y} = C$ (d) $-\frac{x}{y^2}e^{x/y} = C$

Ans. **(a)**

$$\left(1+e^{x/y}\right)\frac{dx}{dy} + e^{x/y}\left(1-\frac{x}{y}\right) = 0$$

$$\left(1+e^{x/y}\right)dx + e^{x/y}\left(1-\frac{x}{y}\right)dy = 0$$

$$\frac{\partial M}{\partial y} = e^{x/y}\left(\frac{-x}{y^2}\right),$$

$$\frac{\partial N}{\partial x} = e^{x/y}\frac{1}{y}\left(1-\frac{x}{y}\right) + e^{x/y}\left(0-\frac{1}{y}\right)$$

$$= e^{x/y}\left(-\frac{x}{y^2}\right)$$

$\therefore$ $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

Differential equation is exact D.E.

General solution:

$$\int_{(y \text{ constant})} M dx + \int_{(\text{terms not having } x)} N dy = C$$

$$\int_{(y \text{ constant})} (1+e^{x/y})\,dx + 0 = C$$

$\Rightarrow$ $x + ye^{x/y} = C$

End of Solution

51. If a force $\vec{F} = 2x^2y\hat{i} + 3xy\hat{j}$ displaces a particle in the xy-plane from (0, 0) to (1, 4) along a curve $y = 4x^2$, what is the work done?

(a) $\frac{102}{5}$ (b) $\frac{5}{104}$

(c) $\frac{104}{5}$ (d) $\frac{5}{102}$

Ans. (c)

$$W = \int_{(C)} \vec{F} \cdot \overrightarrow{dr} = \int_{(C)} (2x^2 y\,dx + 3xy\,dy)$$

$C : y = 4x^2$ from (0, 0) to (1, 4)

$dy = 8x\,dx$

$$= \int_{x=0}^{1} \left[8x^4 + (12x^3)8x\right] dx$$

$$= \left(8\frac{x^5}{5} + 96\frac{x^5}{5}\right)_0^1 = \frac{104}{5}$$

End of Solution

52. A die is tossed thrice. A success is getting 1 or 6 on a toss. Then, mean and variance of the number of successes are

(a) Mean = $\frac{1}{2}$, Variance = $\frac{3}{2}$ (b) Mean = 1, Variance = $\frac{2}{3}$

(c) Mean = $\frac{1}{2}$, Variance = $\frac{2}{3}$ (d) Mean = 1, Variance = $\frac{1}{2}$

Ans. (b)

$n = 3$

Probability of success, $P = \frac{1}{3}$

mean = np variance = npq

$3 \times \frac{1}{3} = 1$ $= 3 \times \frac{1}{3} \times \frac{2}{3} = \frac{2}{3}$

End of Solution

53. In which matrix are eigen vectors corresponding to different eigen values orthogonal?

(a) Singular matrix (b) Non-singular matrix

(c) Symmetric matrix (d) Non-symmetric matrix

Ans. (c)

End of Solution

54. '0' is a characteristic root of a matrix, if and only if, the maltrix is

(a) Idempotent matrix (b) Peridoic matrix

(c) Nilpotent matrix (d) Singular matrix

Ans. **(d)**

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

$$\lambda = 0$$

In singular matrix, $|A| = 0$

End of Solution

55. The value of $\int_0^{\pi/6} \cos^4 3\theta \sin^3 6\theta \, d\theta$ is

(a) $\frac{1}{15}$ (b) $\frac{8}{3}$

(c) $\frac{7}{3}$ (d) $\frac{7}{15}$

Ans. **(a)**

Let, $3\theta = t$

$$d\theta = \frac{dt}{3}$$

$$\int_0^{\pi/2} \cos^4 t \cdot \sin^3 2t \cdot \frac{dt}{3} = \frac{8}{3}\int_0^{\pi/2} \cos^4 t \sin^3 t \, dt$$

$$= \frac{8}{3} \times \frac{6 \times 4 \times 2 \times 2}{10 \times 8 \times 6 \times 4 \times 2} \times 1 = \frac{1}{15}$$

End of Solution

56. The image of the line $I_m(z) = 1$ under the mapping $w = z^2$ is

(a) $u^2 = 4(v + 1)$ (b) $v^2 = 4(u + 1)$

(c) $u = 4(v + 1)$ (d) $v = 4(u + 1)$

Ans. **(b)**

Let, $w = u + iv$ and $z = x + iy$

$$\text{Im}(z) = 1$$

$$y = 1$$

$$w = z^2$$

$$z = x + iy$$

$$z^2 = (x + iy)^2$$

$$= x^2 + i^2y^2 + 2xyi$$

$$u + i\,v = (x^2 - y^2) + i(2xy)$$

$$u = x^2 - y^2, \qquad v = 2xy$$

Put $y = 1$,

$$u = x^2 - 1, \qquad v = 2x$$

$$u + 1 = x^2, \qquad v^2 = 4x^2$$

$$v^2 = 4(u + 1)$$

End of Solution

57. The number of emergency admissions each day to a hospital is found to have Poisson's distribution with mean 4. What is the probability that on a particular day there will be no emergency admissions?

(a) e^{-4} (b) e^{-2}

(c) e^{2} (d) e^{4}

Ans. **(a)**

$$P(x = 0) = \frac{e^{\lambda}\lambda^{x}}{x!} = \frac{e^{-4} \times 4^{0}}{0!} = e^{-4}$$

End of Solution

58. How many seconds would a clock lose per day if the length of its pendulum was increased in the ratio of 900 : 901?

(a) 48 (b) 25

(c) 16 (d) 56

Ans. **(a)**

$$T = 2\pi\sqrt{\frac{l}{g}}$$

T = time period = 3600 sec

So, $T \propto \sqrt{l}$

$$\frac{T_2}{3600} = \frac{\sqrt{900/901}}{\sqrt{1}}$$

$$T_2 = 3600 \times \sqrt{\frac{900}{901}} \approx 3598.00$$

In one hour clock loses = 3600 – 3598 = 2 second

In one day (24 hrs) = clock loses

= 2 × 24 = 48 seconds

End of Solution

59. In estimating the cost of a pile of bricks measured as 2 m × 15 m × 1.2 m, the tape is stretched 1% beyond the standard length. If the count is 450 bricks to 1 cu.m. and bricks cost Rs. 530 per 1000, what is the approximate error in the cost?

(a) Rs. 257.58 (b) Rs. 152.65

(c) Rs. 345.41 (d) Rs. 329.49

Ans. **(a)**

For initial cost,

1 cubic meter = 450 brick

2 × 15 × 1.2 = 30 × 1.2 = 36 cubic meter

36 cubic meter contains brick = 450 × 36 = 16200

$$\text{cost of 16, 200 bricks} = \frac{530}{1000} \times 16200 = 53 \times 162 = 8586$$

$$2^{nd} \text{ volume} = 2 \times 15 \times 1.2 \times 1.01^3 = 37.08 \text{ cubic meter}$$
$$\text{Extra volume} = 1.08 \text{ Cubic meter}$$
$$\text{Bricks in extra area} = 450 \times 1.08 \approx 486$$
$$\text{Extra cost} = \frac{530}{1000} \times 486 \approx 257.58$$

End of Solution

60. Three cities A, B, C are equidistant from each other. One motorist travels from A to B at 20 km/hr., from B to C at 40 km/hr., from C to A at 50 km/hr. What is the average speed?

(a) 38.3 km (b) 31.6 km
(c) 39.2 km (d) 34.6 km

Ans. (b)

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{3x}{\frac{x}{20} + \frac{x}{40} + \frac{x}{50}}$$

$$\Rightarrow \quad \frac{3x}{\frac{10x + 5x + 4x}{200}} = \frac{34 \times 200}{19x} = \frac{600}{19} = 31.59$$

End of Solution

61. What is the line energy of dislocations on BCC iron? The Burgers' vector in iron is of the 1/2 < 111 > type. The shear modulus of iron is 80.2 GN/m^2. Given that the lattice parameters of BCC iron, a = 2.87 Å.

(a) 1.40×10^{-9} J/m (b) 3.12×10^{-9} J/m
(c) 2.476×10^{-9} J/m (d) 6.544×10^{-9} J/m

Ans. (c)

$$\text{Burger vector, } b = \frac{1}{2} \times \sqrt{3}a$$
$$b = 2.48 \times 10^{-10}$$
$$\text{Line energy} = \frac{1}{2}Gb^2 = \frac{1}{2} \times 80.2 \times (2.48 \times 10^{-10})^2 \times 10^9$$
$$= 2.47 \times 10^{-9} \text{ J/m}$$

End of Solution

62. Nichrome is an alloy of
(a) Manganese 2.5%, Nickel 81% to 84%, Chromium 14% to 17% and a little percentage of Iron.
(b) Manganese 2.0%, Nickel 78% to 81%, Chromium 17% to 20% and a little percentage of Iron.
(c) Manganese 1.5%, Nickel 75% to 78%, Chromium 20% to 23% and a little percentage of Iron.
(d) Manganese 0.5%, Nickel 72% to 75%, Chromium 23% to 26% and a little percentage of Iron.

Ans. (c)

End of Solution

63. Which one of the following statements is NOT correct regarding bundle conductors?
(a) Voltage stress at the conductor surface is reduced by using bundle conductors.
(b) Corona loss is smaller by using bundle conductors.
(c) Current carrying capacity is decreased in bundle conductors as compared with a single conductor of equivalent cross-sectional area.
(d) The line having bundle conductors is less liable to cause radio interference.

Ans. (c)

End of Solution

64. What is the loss of energy per hour in a ferromagnetic specimen when it is subjected to 50 Hz magnetisation, if the specimen weighs 50 kg, area of hysteresis loop is 200 joules per m^3 and density of iron is 7500 kg/m^3?
(a) 2.4×10^5 J
(b) 3.9×10^4 J
(c) 2.9×10^4 J
(d) 4.5×10^5 J

Ans. (a)

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{or} \quad V = \frac{M}{\rho}$$

$$\text{Loss of energy per hour} = \frac{50}{7500} \times 200 \times 50 \times 60 \times 60$$
$$= 2.4 \times 10^5 \text{ J}$$

End of Solution

65. A heater element is made of nichrome wire having resistivity equal to 100×10^{-8} Ωm. The diameter of the wire is 0.4 mm. The length of the wire required to get a resistance of 40 Ω and 1000 W is
(a) 5.0 metres
(b) 4.5 metres
(c) 5.5 metres
(d) 4.0 metres

Ans. (a)

$$R = \frac{\rho l}{A} \Rightarrow l = \frac{RA}{\rho}$$

$\rho = 100 \times 10^{-8}\ \Omega\text{-m}$

$d = 0.4 \times 10^{-3}$ m

$R = 40\ \Omega$

$$= \frac{40 \times 1.256 \times 10^{-7}}{100 \times 10^{-8}}$$

$l = 5.024$ m

End of Solution

66. The lead material works as superconductor at a temperature of $T_c = 7.26$ K. If the constant characteristics of the lead material at 0 K is $H_0 = 8 \times 10^5$ A/m, then what is the magnetic field in the lead at 5 K?

(a) $\frac{8 \times 10^5}{\pi}$ A/m

(b) $\frac{4 \times 10^5}{4\pi}$ A/m

(c) $\frac{10^5}{2\pi}$ A/m

(d) $4\pi \times 10^5$ A/m

Ans. (*)

$$H_c = 8 \times 10^5 \left(1 - \left(\frac{5}{7.26}\right)^2\right)$$

$= 4.2 \times 10^5$ A/m

End of Solution

67. What is the approximate lattice constant "*a*" of a substance having FCC lattice, molecular weight 60.2 and density 6250 kg/m^3? (Consider $N = 6.02 \times 10^{26}$/kg-mole)

(a) 5×10^{-10} m

(b) 3×10^{-10} m

(c) 4×10^{-10} m

(d) 8×10^{-10} m

Ans. (c)

$A = 60.2$

$\rho = 6250$ kg/m^3

$N_A = 6.02 \times 10^{26}$ kg-mol

$$\Rightarrow \quad \frac{n}{V_C} = \frac{N_A \rho}{A}$$

$$= \frac{6.02 \times 10^{26} \times 6250}{60.2}$$

$$\Rightarrow \quad \frac{n}{V_C} = 625 \times 10^{26}$$

$$\Rightarrow \quad V_c = \frac{n}{625\times10^{26}} = \frac{4}{625\times10^{26}} = a^3$$

$$a = 4 \times 10^{-10} \text{ m}$$

End of Solution

68. Which one of the following statements is NOT correct regarding dielectric loss?
(a) The loss increases proportionately with the frequency of applied voltage.
(b) Presence of humidity increase the loss.
(c) Temperature rise normally decreases the loss.
(d) Voltage increase causes increased dielectric loss.

Ans. (c)

End of Solution

69. In a ferromagntic material, the losses due to hysteresis are
(a) directly proportional to the supply frequency.
(b) inversely proportional to the supply frequency.
(c) inversely proportional to square of the supply frequency.
(d) directly proportional to square of the supply frequency.

Ans. (a)

$$P_{HYS} = \eta B^n f$$

End of Solution

70. Which one of the following statements is NOT correct regarding tungsten, which is used as filament material?
(a) It has the highest melting point amongst all metals.
(b) It can be drawn into very thin wires.
(c) It has very high tensile strength in its thinnest form.
(d) It becomes brittle at high temperature.

Ans. (d)

End of Solution

71. The spontaneous magnetization is the most important characteristic of
(a) paramagnetic mateials.
(b) ferromagnetic materials.
(c) diamagnetic materials.
(d) permalloy

Ans. (b)

End of Solution

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72. What is the temperature coefficient of resistance of material used in a resistor if the resistance at 25°C is 50 Ω and at 70°C is 57.2 Ω?

(a) $\frac{1}{168.5}$ (b) $\frac{1}{378.5}$

(c) $\frac{1}{463.5}$ (d) $\frac{1}{287.5}$

Ans. (d)

$$\frac{50}{57.2} = \frac{R_o(1+\alpha\times 25)}{R_o(1+\alpha\times 70)}$$

$$\Rightarrow \quad 50 + \alpha \times 50 \times 70 = 57.2 + \alpha \times 25 \times 572$$

$$\Rightarrow \quad \alpha(3500 - 1430) = 7.2$$

$$\alpha = \frac{1}{287.5}$$

End of Solution

73. One of the primary purposes of using feedback in control systems is to

(a) increase the sensitivity of the system to parameter variations.

(b) reduce the sensitivity of the system to parameter variations.

(c) increase the effect of distortion.

(d) reduce the bandwidth of the system.

Ans. (b)

Reduce sensitivity to parameter variations

End of Solution

74. Transfer function of the system is given by $G(s) = \frac{1000}{(1+0.1s)(1+0.001s)}$. The corner frequency ω_1 and ω_2 for the system are respectively,

(a) 2 rad/sec and 4 rad/sec (b) 8 rad/sec and 10 rad/sec

(c) 100 rad/sec and 10 rad/sec (d) 10 rad/sec and 1000 rad/sec

Ans. (d)

$$\text{T.F.} = T(s) = \frac{10^3}{(1+0.1s)(1+0.001s)}$$

Compare Q^{th} $(1 + Ts)$

$1 + 0.1s \Rightarrow 1 + Ts \Rightarrow T = 0.1$

Corner frequency, $\omega_1 = \frac{1}{T} = \frac{1}{0.1} = 10$ rad/sec

$1 + 0.001s \Rightarrow 1 + Ts$

Corner frequency, $\omega_2 = \frac{1}{T} = \frac{1}{0.001} = 1000$ rad/sec

End of Solution

75. Which one of the following statements is NOT correct with respect to cascade lead compensator?

(a) The undamped natural frequency ω_n is increased considerably which reduces the settling time.

(b) It is used to improve the transient response of the given system.

(c) It is used to improve the steady state performance of the given system.

(d) The phase angle contribution to the root-loci is positive at the dominant pole position.

Ans. **(c)**

Lead compensator cannot improve steady state performance.

End of Solution

76. Which of the following is powerful frequency domain method of extracting the information regarding stability as well as relative stability of a system without the need to evaluate roots of the characteristic equation?

(a) Routh criterion only

(b) Root locus method only

(c) Both Routh criterion and Root locus method

(d) Nyquist criterion

Ans. **(d)**

Nyquist criteria

End of Solution

77. Consider the following system:

$$\begin{bmatrix}\dot{x}_1(t)\\ \dot{x}_2(t)\end{bmatrix} = \begin{bmatrix}-0.5 & 0\\ 0 & -2\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u(t) \text{ and } y(t) = \begin{bmatrix}0 & 1\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}.$$

The system is

(a) controllable and observable

(b) uncontrollable only

(c) unobservable only

(d) uncontrollable and unobservable

Ans. **(d)**

$$\text{Controllability} = [B \quad AB]$$

$$AB = \begin{bmatrix}-0.5 & 0\\ 0 & -2\end{bmatrix}\begin{bmatrix}0\\ 1\end{bmatrix} = \begin{bmatrix}0\\ -2\end{bmatrix}$$

$$Q_C = \begin{bmatrix}0 & 0\\ 1 & -2\end{bmatrix} = 0 \text{ (Uncontrollable)}$$

$$\text{Observability} = [C^T \quad A^TC^T]$$

$$A^TC^T = \begin{bmatrix}-0.5 & 0\\ 0 & -2\end{bmatrix}\begin{bmatrix}0\\ 1\end{bmatrix} = \begin{bmatrix}0\\ -2\end{bmatrix}$$

$$Q_0 = \begin{bmatrix}0 & 0\\ 1 & -2\end{bmatrix} = 0 \text{ (Unobservable)}$$

End of Solution

78. Which one of the following is **not** correct with reference to proportional-derivative (PD) controller?

(a) PD control action reduces rise of the system.
(b) PD control action improves the damping.
(c) PD control action decreases the bandwidth.
(d) PD control action reduces the overshoot.

Ans. **(c)**

A PD controller does not decrease Band width.

End of Solution

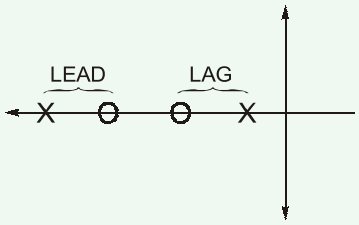
79. Consider the following statements for lag-lead compensator:

1. It is a combination of a lag compensator and a lead compensator.
2. The lag-section has one real pole and one real zero with the pole to the right of the zero.
3. The lead-section has one real pole and one real zero with the zero to the right of the pole.

Which of the above statements are correct?

(a) 1 and 3 only
(b) 2 and 3 only
(c) 1 and 2 only
(d) 1, 2 and 3

Ans. **(d)**



LAG-LEAD COMPENSATOR

End of Solution

80. The ramp response for a system whose transfer function $G(s) = \dfrac{s}{(s+4)(s+8)}$ is

(a) $c(t) = \dfrac{1}{2}e^{-4t} + \dfrac{1}{2}e^{-8t}$
(b) $c(t) = \dfrac{1}{2}e^{-4t} - \dfrac{1}{2}e^{-8t}$
(c) $c(t) = \dfrac{1}{32} - \dfrac{1}{16}e^{-4t} + \dfrac{1}{32}e^{-8t}$
(d) $c(t) = \dfrac{1}{32} - \dfrac{1}{12}e^{-4t} - \dfrac{1}{16}e^{-8t}$

Ans. **(c)**

$$\text{T.F.} = G(s) = \frac{s}{(s+4)(s+8)}$$

$$\text{Ramp Response} = \frac{s}{s^2(s+4)(s+8)}$$

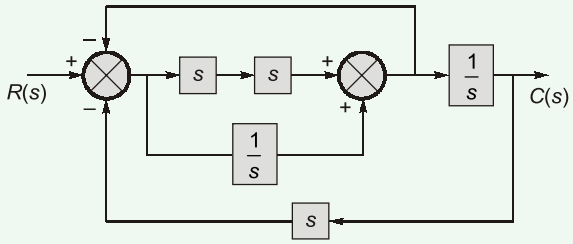
$$= \frac{1}{s(s+4)(s+8)} = \frac{A}{s} + \frac{B}{s+4} + \frac{C}{s+8}$$

$$A = \frac{1}{32},\ B = -\frac{1}{16},\ C = \frac{1}{32}$$

$$\text{Ramp response} = \frac{1}{32} - \frac{1}{16}e^{-4t} + \frac{1}{32}e^{-8t}$$

End of Solution

81. In the figure, if $C(s)$ is the Laplace transform of the output and R(s) is the Laplace transform of the input, the equivalent transfer function $T(s)$ is



(a) $T(s) = \dfrac{s^3+1}{2s^4+s^2+2s}$

(b) $T(s) = \dfrac{s^3+1}{2s^4+s^2-s}$

(c) $T(s) = \dfrac{s^3+1}{2s^4+s^2+1}$

(d) $T(s) = \dfrac{s^3-1}{2s^4+s^2+2}$

Ans. **(a)**

$$\text{T.F.} = \frac{P_1\Delta_1 + P_2\Delta_2}{1-(\text{Independent Loops})}$$

$$P_1 = \frac{1}{s}\cdot s^2 = s\ ;\ \Delta_1 = 1$$

$$P_2 = \frac{1}{s^2}\ ;\ \Delta_2 = 1$$

$$\Delta = 1-\left(-s^2 - s^2 - \frac{1}{s} - \frac{1}{s}\right)$$

$$\text{T.F.} = \frac{s+\dfrac{1}{s^2}}{1-\left(-s^2 - s^2 - \dfrac{1}{s} - \dfrac{1}{s}\right)}$$

$$\frac{\frac{s^3+1}{s^2}}{1-\left(\frac{-2s^3-2}{s}\right)} = \frac{\frac{s^3+1}{s^2}}{\frac{s+2s^3+2}{s}}$$

$$\text{T.F.} = \frac{s^3+1}{2s^4+s^2+2s}$$

End of Solution

82. Consider the following statements related to stability of the control system:

1. Poles in right half-plane (rhp) yield pure exponential decaying natural response.
2. If poles of multiplicity greater than one are present on the imaginary axis, then the system is marginally stable.
3. If one pole is present in right-half plane, the system is unstable.
4. A system is stable if the natural response approaches zero as time approaches infinity.

Which of the above statements is/are **not** correct?

(a) 1 and 4 only (b) 1 and 2 only
(c) 1 only (d) 3 and 4 only

Ans. (b)

End of Solution

83. The state equation and the output equations of the system are as follows:

$$\dot{x} = \begin{bmatrix} 0 & 1 & 2 \\ 5 & 6 & 9 \\ 5 & 3 & 9 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} u \; ; \; y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x$$

where x is the state variable, u is the input variable and y is the output variable. What is the number of right-half poles?

(a) 0 (b) 1
(c) 2 (d) 3

Ans. (c)

$$|sI - A| = 0$$

$$\begin{bmatrix} s & 0 & 0 \\ 0 & s & 0 \\ 0 & 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 & 2 \\ 5 & 6 & 9 \\ 5 & 3 & 9 \end{bmatrix} = 0$$

$s[(s-6)(s-9)-27] + 1[-5(s-9)-45] - 2[15+5(s-6)]] = 0$

Negative coefficient. So two roots will lie in R.H.S. of s-plane.

End of Solution

84. In minimum phase transfer function, the transfer functions have
(a) neither poles nor zeros in the right-half *s*-plane
(b) poles in right-half *s*-plane and zeros in left-half *s*-plane.
(c) poles in left-half *s*-plane and zeros in right-half *s*-plane.
(d) poles and zeros in the right-half s-plane.

Ans. (a)

End of Solution

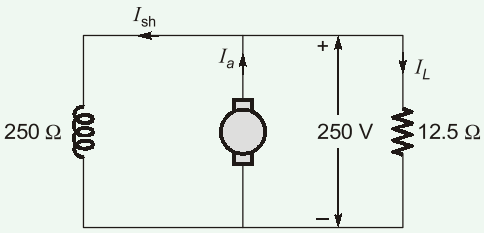
85. Which one of the following statements is NOT correct regarding lap and wave winding?
(a) Lap-winding is suitable for high-voltage but low-current generators.
(b) Lap-winding is suitable for low-voltage but high-current generators.
(c) Wave-winding is used for high-voltage, low-current machines.
(d) When large currents are required, it is necessary to use lap-winding.

Ans. (a)
Lap : A increases, current rating increases
Wave : $A = 2$, Low current

End of Solution

86. An 8-pole DC shunt generator with 778 wave-connected armature conductors and running at 500 rpm supplies a load of 12.5 Ω resistance at terminal voltage of 250 V. The armature resistance is 0.24 Ω and field resistance is 250 Ω. The magnitude of armature current is
(a) 20 A
(b) 10 A
(c) 21 A
(d) 11 A

Ans. (c)



$I_a = ?$
$V = 250$
$R_{sh} = 250$

$$I_{sh} = \frac{V}{R_{Sh}} = 1 \text{ A}$$

$$I_L = \frac{V}{R_L} = \frac{250}{12.5} = 20 \text{ A}$$

$$I_a = I_L + I_{sh} = 21 \text{ A}$$

End of Solution

87. A 12-pole, 3-phase alternator driven at a speed of 500 rpm, supplies power to an 8-pole, 3-phase induction motor. If the slip of the motor at full-load is 3%, what is the full-load speed of the motor?

(a) 525.5 rpm (b) 627.5 rpm
(c) 727.5 rpm (d) 826.5 rpm

Ans. **(c)**

3-ϕ alternator, $N_s = 500$ rpm, $f = \dfrac{PN}{120}$

$$f = \frac{12 \times 500}{120} = 50 \text{ Hz supply to I.M.}$$

I.M. = 8P $\Rightarrow$ $N_s = \dfrac{120 \times 50}{8} = 750$ rpm

$$N = N_s(1 - s) = 750(1 - 0.03)$$
$$= 727.5 \text{ rpm}$$

End of Solution

88. A 300 kVA, single-phase transformer is designed to have a resistance of 1.5% and maximum efficiency occurs at a load of 173.2 kVA. What is the efficiency when supplying full-load at 0.8 pf lagging at normal voltage and frequency?

(a) 68.2% (b) 76.3%
(c) 89.1% (d) 97.6%

Ans. **(d)**

300 kVA, 1-ph T/F, $R = 1.5\%$

Max. η @ load 173.2 KVA

$$\eta_{FL} = 0.8 \text{ pf lagg}$$

x : Load @ max $h = \dfrac{173.2}{300} = 0.577 = \dfrac{1}{\sqrt{3}}$

$$\% R = \% \text{ Cu loss} = 1.5\%$$

$\Rightarrow$ 1.5% (300 kW) = 4500 W (F.L. Cu loss)

$$x^2 P_{Cu} = \text{Const. loss}$$

$$\left(\frac{1}{\sqrt{3}}\right)^2 (4500) = 1500 \text{ W}$$

$$\eta_{0.8,FL} = \frac{300 \times 10^3 \times 0.8}{300 \times 10^3 \times 0.8 + 1500 + 4500}$$

$$= \frac{240000}{246000} = 0.9756 \text{ or } 97.56\%$$

End of Solution

89. A sinusoidal flux 0.02 Wb links with 55 turns of a transformer secondary. What is the rms value of the induced emf in the secondary, if the supply frequency is 50 Hz?

(a) 244.2 V (b) 334.2 V
(c) 414.2 V (d) 504.2 V

Ans. **(a)**

$$\phi = 0.02 \text{ Wb}$$
$$N_2 = 55 \text{ turns}$$

rms value of the induced emf in the secondary,

$$= 4.44\ \phi f N_2 = 4.44 \times 0.02 \times 50 \times 55$$
$$= 244.2 \text{ V}$$

End of Solution

90. A stepper motor with a step angle of 15° has a stepping frequency of 300 steps/sec. What is the motor speed?

(a) 750 rpm (b) 650 rpm
(c) 780 rpm (d) 950 rpm

Ans. **(a)**

Stepping frequency or pulse rate = Pulses per second (PPS)

If α is step angle

$$\text{Motor speed, } r = \frac{\alpha \times f}{360} \text{ rps}$$

Given : $\alpha = 15°$, $f = 300$ steps/sec

$$n = \frac{15 \times 300}{360} = 12.5 \text{ rps}$$

$$n \text{ in rpm} = 12.5 \times 60 = 750 \text{ rpm}$$

End of Solution

91. If P_1 and P_2 be the iron and copper losses of a transformer on full-load, what is the ratio of P_1 and P_2 such that maximum efficiency occurs at 75% full-load?

(a) $\frac{4}{3}$ (b) $\frac{3}{4}$
(c) $\frac{5}{7}$ (d) $\frac{9}{16}$

Ans. **(d)**

P_1 : Tran loss; P_2 : Cu loss at full load

$$x = 0.75$$

$$x = \sqrt{\frac{P_1}{P_2}} = 0.75$$

$$\frac{P_1}{P_2} = \frac{9}{16}$$

End of Solution

92. Which one of the following statements is **not** correct regarding simplex lap winding of a DC machine?

(a) The total number of brushes is equal to the number of poles.
(b) The number of parallel paths in the armature is two.
(c) The emf between the positive and the negative brushes is equal to the emf generated in any one of the parallel paths.
(d) If Z is the total number of armature conductors and P is the number of poles, then the number of armature conductors in any parallel path is Z/P.

Ans. **(b)**

Simplex lap : $\#B = \#P$

$A = P \times M$

$\frac{Z}{A} = \frac{\text{Cond}}{\text{Path}}$

End of Solution

93. The single-phase reluctance machine can be made to work as a generator when mechanical power is supplied to the shaft. This is possible when

(a) mechanical power is increased and angle becomes negative.
(b) mechanical power is increased and angle becomes positive.
(c) Mechanical power is decreased and angle becomes 60°.
(d) Mechanical power is decreased and angle becomes 45°.

Ans. **(b)**

End of Solution

94. If the flux linkage-current characteristic is linear, then

(a) the field energy is greater than the coenergy.
(b) the field energy is less than the coenergy.
(c) the field energy is equal to the coenergy.
(d) the field energy and the coenergy do not have any dependence on flux linkage-current characteristic.

Ans. **(c)**

End of Solution

95. An 8-pole generator has an output of 200 A at 500 V, the lap-connected armature has 1280 conductors, 160 commutator segments. If the brushes are advanced 4-segments from the no-load neutral axis, what is the cross-magnetizing ampere-turns per pole?

(a) 1600 (b) 1400
(c) 1550 (d) 1200

Ans. **(d)**

$P = 8,\ I_L = 200\ \text{A},\ V = 500\ \text{V}$

Lap : $A = 8,\ Z = 1280,\ \text{Com Seg} = 160$

Brush shift : 4 Segments

$$\frac{AT_C}{P} = \left(\frac{180-2\theta_e}{180}\right)\left(\frac{I_a}{A}\cdot\frac{Z}{2P}\right)$$

$$\frac{360°}{160} = 2.25° \text{ Mech/Segment}$$

4 Seg $\Rightarrow$ $4 \times 2.25 = 9$

$$\theta_e = \frac{P}{2}\theta_M \Rightarrow \frac{8}{2}\times 9 = 36° \text{ electrical}$$

$$\frac{AT_C}{P} = \left(\frac{180-2\times 36}{180}\right)\left(\frac{200}{8}\times\frac{1280}{2\times 8}\right)$$

$= (0.6)(2000)$

$= 1200$ AT/P

End of Solution

96. A 400 V, 1000 A, lap-wound DC machine has 10 poles and 860 armature conductors. What is the number of conductors in the pole face to give full compensation if the pole face covers 70% of the pole span?

(a) 1000 (b) 4000

(c) 2050 (d) 3010

Ans. **(*)**

Compensating winding ampere turns per pole = Armature winding ampere turns per pole

$$= 0.7\left(\frac{I_a}{A}\times\frac{Z}{2P}\right)$$

$$= 0.7\left(\frac{1000}{10}\times\frac{860}{2\times 10}\right)$$

$= 0.7(4300)$

$= 3010$ AT/pole

but in question, number of conductors is asked.

End of Solution

97. The main function of electric power system is to

(a) transmit energy with maximum efficiency.

(b) generate energy with minimum efficiency.

(c) store energy with maximum efficiency.

(d) convert energy with minimum efficiency.

Ans. **(a)**

End of Solution

98. Which of the following are the sources of heat generation within the cables?
1. I^2R losses in the conductor.
2. Dielectric losses in the cable insulation.
3. Losses in the metallic sheath and armourings.

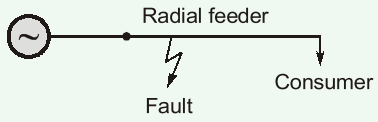
Select the correct answer using the code given below:
(a) 1 and 2 only
(b) 1, 2 and 3
(c) 2 and 3 only
(d) 1 and 3 only

Ans. (b)

End of Solution

99. The radial distribution is simple and economical, but the reliability of the system is poor and leads to
(a) evacuating of energy supply if there fault in the line.
(b) transmission of energy supply if there fault in the line.
(c) distribution of energy supply if there fault in the line.
(d) interruption of energy supply if there fault in the line.

Ans. (d)



End of Solution

100. Which one of the following statements is correct regarding fault analysis?
(a) Balanced three-phase voltages contain zero-sequence components.
(b) Balanced three-phase voltages do not contain negative sequence components.
(c) Balanced three-phase voltages contain only negative sequence components.
(d) Balanced three-phase voltages contain positive and negative sequence components.

Ans. (b)

End of Solution

101. For a single-line to ground fault, the terminal conditions are
(a) $V_a = 0,\ I_b = I_c = 0$
(b) $I_a = -I_c,\ V_a = V_c$
(c) $I_a = I_c,\ V_b = V_c$
(d) $I_a = 0,\ V_b = V_c$

Ans. (a)

End of Solution

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102. The per unit impedance of a circuit element is x. If the base kV and base MVA are doubled, then the new value of the per unit impedance of the circuit element is

(a) x (b) $\frac{x}{2}$

(c) $2x$ (d) $\frac{x}{4}$

Ans. **(b)**

The per unit impedance,

$$X_n = X_0 \frac{S_{bn}}{S_{b0}} \times \left(\frac{V_{b0}}{V_{bn}}\right)^2$$

When kVA and kV are doubled

$$X'_n = x \cdot \frac{2S_{b0}}{S_{b0}} \cdot \left(\frac{V_{b0}}{2V_{b0}}\right)^2$$

$$X_n = \left(\frac{X}{2}\right)$$

End of Solution

103. The fill factor of a photovoltaic module is 0.8. A single cell in a module has an open circuit voltage of 0.6 V and short circuit current of 8 A. The module has 48 cells connected in series. If the voltage at maximum power is 0.9 times open circuit voltage, the current at maximum power is

(a) 8.21 A (b) 7.11 A

(c) 6.32 A (d) 5.45 A

Ans. **(b)**

Given: FF of module = 0.8

V_{OC} = 0.6 V, I_{SC} = 8 A

For 48 cells in series V_{OC} = 48 × 0.6

I_{SC} = 8 A (Remains same)

Voltage at maximum power,

V_m = 0.9 V_{OC} = 0.9 × 48 × 0.6

I_m = ?

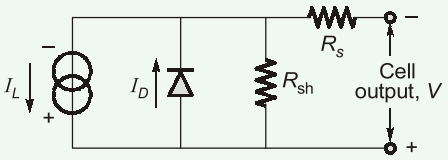
$$\text{Fill factor, FF} = \frac{I_m V_m}{(I_{SC})(V_{OC})}$$

$$I_m = \frac{48 \times 0.6 \times 8 \times 0.8}{0.9 \times 48 \times 0.6} = \frac{8 \times 0.8}{0.9}$$

I_m = 7.11 A

End of Solution

104. The equivalent circuit of a photovoltaic module is presented below:



The requirements for more power production are

(a) I_L should be maximum, R_s should be large, R_{sh} should be small.

(b) I_L should be minimum, R_s should be small, R_{sh} should be large.

(c) I_L should be maximum, R_s should be small, R_{sh} should be large.

(d) I_L should be minimum, R_s should be large, R_{sh} should be small.

Ans. **(c)**

As $I_L \rightarrow$ high, $R_S \rightarrow$ low and $R_{Sh} \rightarrow$ high

End of Solution

105. Electricity supply systems are invariably three-phase and they are so designed and loaded that the operation is

(a) star connected (b) balanced three-phase

(c) unbalanced three-phase (d) delta connected.

Ans. **(b)**

End of Solution

106. Which one of the following power plants is the least reliable?

(a) Tidal (b) Solar

(c) Wind (d) Geothermal

Ans. **(c)**

Wind energy is least reliable source of electric energy.

End of Solution

107. When a synchronous motor runs at no load with adjustable excitation over a wide range, power factor can be improved by varying the excitation of its

(a) field winding (b) armature winding

(c) commutator winding (d) compound winding

Ans. **(a)**

End of Solution

108. What is the maximum number of points of light, fans and 5 A socket outlets that can be connected in one circuit as per recommendation of Indian Standards?

(a) 8 (b) 10

(c) 12 (d) 9

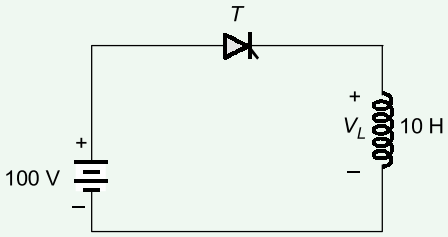
Ans. **(b)**

End of Solution

109. A DC supply of 100 V feeds an inductance of 10 H through a thyristor. What is the minimum width of the gate pulse so that the thyristor is triggered, if the latching current of thyristor is 80 mA?

(a) More than 8 ms
(b) Less than 8 ms
(c) Exact 6 ms
(d) Less than 6 ms

Ans. (a)



At $t = 0$, we give gate signal to Thyristor,

then for $t \geq 0$

$$V_L = V_S$$

$$V_S = L \cdot \frac{di}{dt}$$

$$di = \frac{V_S}{L} \cdot dt$$

$$i = \frac{V_S}{L} \cdot t$$

$$I_L = \frac{V_S}{L} \cdot t_{min}$$

$$t_{min} = \frac{I_L \cdot L}{V_S} = \frac{80.10^{-3} \times 10}{100} = 8 \text{ ms}$$

$\therefore$ $t_{gpw} > t_{min}$

$t_{gpw} > 8$ ms

End of Solution

110. Consider the following statements with regards to IGBTs:

1. At highest temperature, maximum current rating goes down to 2/3 value.
2. IGBT is the preferred device for applications that require high blocking voltages and lower operating frequencies.
3. Turn-on transients are identical to MOSFETs.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (c)

IGBT is the preferred device for application that require high operating frequencies and in high volt applications.

The current and voltage waveform for the turn-ON of an IGBT embedded in a converter circuit similar to that for the MOSFET. The turn ON portion of the waveform appear similar to those of the power MOSFET.

End of Solution

111. What is the supply frequency for the case hardening of shaft having specific resistivity of 5 x 10^{-5} Ω-cm and the relative permeability equal to 1 for depth of heating 2.5 mm?

(a) 20.24 kHz (b) 26.24 kHz

(c) 15.62 kHz (d) 32.15 kHz

Ans. (a)

Given resistivity, $\rho = 5 \times 10^{-5} \times 10^{-2} = 5 \times 10^{-7}$ Ω-m

$\mu_r = 1$; Skin depth, $\delta = 2.5 \times 10^{-3}$ m

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

Squaring both sides in above equation,

$$\pi f \mu \sigma = \frac{1}{\delta^2}$$

As conductivity, $\sigma = \frac{1}{\rho}$

or
$$f = \frac{\rho}{\delta^2 \cdot \pi \times \mu_0} = \frac{5 \times 10^{-7}}{(2.5 \times 10^{-3})^2 \times \pi \times 4\pi \times 10^{-7}}$$

$$= 20.26 \text{ kHz}$$

End of Solution

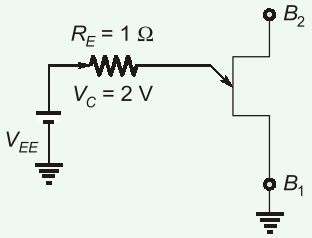
112. If R_E = 1 kΩ, V_E = 2 V and I_V = 5 mA, what is the value of V_{EE} which will cause the UJT to turn 'off'?

(a) 2 V (b) 5 V

(c) 9 V (d) 7 V

Ans. (a)

R_E = 1 kΩ
V_E = 2 V
I_V = 5 mA
V_{EE} = ?
$V_E = V_o + \eta V_{BB} = 2$ V



$$= 0.7 + 1.3 \text{ V}$$

$$V_{EE} = V_E = 2 \text{ V}$$

Then UJT turn off.

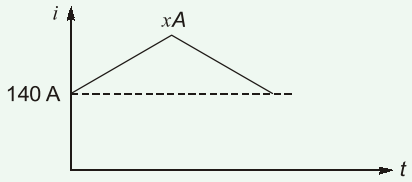
End of Solution

113. In a 110 V DC chopper drive using the CLC scheme, the maximum possible value of the accelerating current is 300 A. The lower limit of the current pulsation is 140 A. What is the maximum limit of current pulsation?

(a) 140 A (b) 440 A

(c) 160 A (d) 150 A

Ans. (b)



$$x - 140 = 300 \text{ A}$$

$$x = 300 + 140$$

$$x = 440 \text{ A}$$

End of Solution

114. A three-phase, squirrel-cage induction motor is developing torque of 1500 sync.watts at 50 Hz and 1400 rpm (synchronous speed is 1500 rpm). If the motor frequency is now increased to 75 Hz using constant power mode, what is the new value of torque developed by the motor at constant slip?

(a) 1500 synch. watts (b) 7500 synch. watts

(c) 1000 synch. watts (d) 2250 synch. watts

Ans. (c)

$$T = 1500 \text{ synch W}$$

50 Hz 1400 rpm (N_s given 1500 rpm)

$$S = \frac{1500 - 1400}{1500} = \frac{100}{1500} = 0.0666$$

F increases 75 Hz, $N_s = \frac{120 \times 75}{4} = 2250$ rpm

Const. Power Mode : $P = \frac{2\pi NT}{60}$

$P \propto NT$,

$$N_1 T_1 = N_2 T_2$$

$$1400 \times 1500 = N_{S2}(1 - S_2) T_2$$

$$1400 \times 1500 = 2250(1 - 0.0666) T_2$$

$$T_2 = \frac{1400 \times 1500}{2250(1 - 0.0666)} = 1000 \text{ synch W}$$

End of Solution

115. A UPS is driving a 600 W load which has a lagging power factor of 0.8. The efficiency of the inverter is 80%. The battery voltage is 24 V DC. Assume that there is a separate charger for the battery. What is the rating of the inverter?

(a) 1.5 kVA (b) 0.5 kVA
(c) 0.75 kVA (d) 2.5 kVA

Ans. **(a)**

$$P_0 = V_{0r} I_{0r} \cdot \text{PF}$$
$$600 = V_{0r} I_{0r} \cdot 0.8$$
$$V_{0r} I_{0r} = \frac{600}{0.8} = 0.75 \text{ kVA}$$

$\therefore$ Rating should be atleast greater than 0.75 kVA.

From given options nearest one greater than 0.75 kVA is 1.5 kVA (Considering safety factor 2).

$$\text{kVA rating} = 0.75 \times 2 = 1.5 \text{ kVA}$$

Therefore, we can consider rating of inverter is 1.5 kVA

End of Solution

116. A boost converter having an input voltage of 20 V is connected to a resistive load. The value of inductance is 1 mH with an equivalent series resistance of 0.1 Ω. If the duty ratio of the converter is one, then the output voltage is

(a) zero (b) 20 V
(c) 40 V (d) infinte

Ans. **(a)**

Boost converter, $V_0 = \dfrac{V_S(1-\alpha)}{\frac{r}{R} + (1-\alpha)^2}$

$\alpha = 1,\ V_0 = 0$

End of Solution

117. In comparing the operation of the half-controlled 2-pulse circuit with that of the fully-controlled circuit, which of the following statements are evident?

1. Since half the thyristors are replaced by diodes, a half-controlled converter costs less than a fully-controlled converter.
2. Due to the freewheeling action with half-controlled bridge-circuit power factor is improved in half-controlled converters.
3. The AC supply current is more distorted due to its zero periods with half-controlled circuit, compared to fully-controlled bridge-circuit.

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

The AC supply current is improved with half controlled circuit, compared to fully controlled bridge circuit.

End of Solution

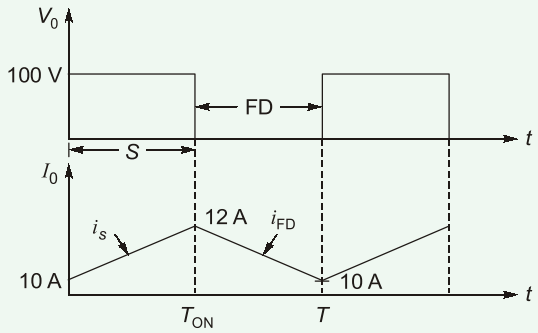
118. A DC chopper circuit connected to a 100 V DC source supplies an inductive load having 40 mH in series with a resistance of 5 Ω. A freewheeling diode is placed across the load. The load current varies between the limits of 10 A and 12 A. What is the time ratio of the chopper?

(a) 12.22 (b) 1.222

(c) 2.111 (d) 21.11

Ans. (b)

Stepdown chopper:



$$\tau = \frac{L}{R} = \frac{40.10^{-3}}{5} = 8.10^{-3}$$

$$V_0 = \alpha V_s$$

$S \rightarrow$ ON:

$$V_S = Ri_s + L\frac{di_s}{dt}$$

$$i_s = \frac{V_S}{R}\left(1 - e^{-t/8.10^{-3}}\right) + 10 \cdot e^{-t/8.10^{-3}}$$

$$= \frac{100}{5}\left(1 - e^{-t/8.10^{-3}}\right) + 10 \cdot e^{-t/8.10^{-3}}$$

$$= 20\left(1 - e^{-t/8.10^{-3}}\right) + 10 \cdot e^{-t/8.10^{-3}}$$

$$i_s = 20 - 10\,e^{-t/8.10^{-3}}$$

At $t = T_{ON}$, $i_s = 12$ A

$\therefore$ $12 = 20 - 10\,e^{-t/8.10^{-3}}$

$$10\,e^{-T_{ON}/8.10^{-3}} = 8$$

$$e^{-T_{ON}/8.10^{-3}} = 0.8$$

$$\frac{-T_{ON}}{8.10^{-3}} = -0.223$$

$$T_{ON} = 1.785 \times 10^{-3} = 1.785 \text{ ms}$$

FD → ON:

$$i_{FD} = 12 \cdot e^{-t'/\tau}$$

$$= 12 \cdot e^{-t'/8.10^{-3}}$$

At $t' = T_{OFF}$, $i_{FD} = 10$ A

$$10 = 12 \cdot e^{-T_{OFF}/8.10^{-3}}$$

$$e^{-T_{OFF}/8.10^{-3}} = \frac{10}{12}$$

$$\frac{-T_{OFF}}{8.10^{-3}} = -0.182$$

$$T_{OFF} = 1.458 \text{ ms}$$

$$\text{Time ratio} = \frac{T_{ON}}{T_{OFF}} = \frac{1.785}{1.458} = 1.22$$

Alternate Solution :

$$I_{o(avg)} = \frac{I_{o(max)} + I_{o(min)}}{2}$$

$$I_{o(avg)} = \frac{12+10}{2} = 11 \text{ A}$$

$$V_{o(avg)} = I_{o(avg)} \times R$$

$$= 11 \times 5 = 55 \text{ V}$$

and $$V_{o(avg)} = \frac{T_{on}}{T} V_s$$

$$\frac{55}{100} = \frac{T_{on}}{T}$$

$$\frac{T_{off}}{T} = \frac{T - T_{on}}{T} = \frac{45}{100} T$$

So, $$\frac{T_{on}}{T_{off}} = \frac{55}{45} = \frac{11}{9} = 1.222$$

End of Solution

119. What is the minimum capacitance for the supply transformer rated 5 kVA with secondary voltage of 120 V RMS and switching frequency of 400 Hz?

(a) 0.92 μF (b) 0.76 μF

(c) 0.52 μF (d) 0.25 μF

Ans. (*)

Unclear data in question.

End of Solution

120. A 220 V, 960 rpm, 80 A, separately excited DC motor has an armature resistance 0.06 Ω. Under rated conditions, the motor is driving a load whose torque is constant and independent of speed. The speeds below the rated speed are obtained with armature voltage control and the speeds above the rated speed are obtained by field control. What is the motor terminal voltage, when the speed is 620 rpm ?

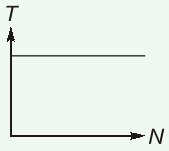
(a) 68.98 V (b) 143.78 V
(c) 215.22 V (d) 320.11 V

Ans. **(b)**

220 V, 960 rpm, 80 A, separately excited DC motor

$R = 0.06\ \Omega$

V at $N_2 = 620$ rpm



V. control : $\dfrac{N_2}{N_1} = \dfrac{E_{b2}}{E_{b1}}$

$N_1 = 960,\ I_{a1} = 80\ \text{A},\ R_a = 0.06$

$E_{b1} = V - I_aR_a = 220 - 80(0.06)$

$= 215.2\ \text{V}$

$N_1 = 960$ rpm

$T \propto I_a \therefore$ $I_{a2} = I_{a1}$

$\dfrac{620}{960} = \dfrac{E_{b2}}{215.2} \Rightarrow E_{b2} = 138.98\ \text{V}$

$V_2 = E_{b2} + I_aR_a = 138.983 + 80(0.06)$

$= 143.78\ \text{V}$

End of Solution

121. The function of an AM detector is to demodulate the AM signal and recover

(a) the original source same frequencies and same amplitude characteristics.
(b) the original source information with up-converted frequencies.
(c) the original signal with amplified output voltage.
(d) the original source information with various frequencies and different amplitude characteristics.

Ans. **(a)**

End of Solution

122. Which one of the following statements is correct for the active filter using op-amps?
(a) High frequency response is limited by the gain bandwidth product and slew-rate of the op-amp.
(b) Op-amps are not providing any gain.
(c) Due to the low input impedance of the op-amp, large value resistors can be used.
(d) High frequency active filters are not more expensive than passive filters.

Ans. (a)

End of Solution

123. What is the value of the full scale output for an 8-bit digital to analog converter for 0 V to 10 V range?
(a) 6.961 V (b) 7.891 V
(c) 8.961 V (d) 9.961 V

Ans. (d)

$$\text{Full scale output} = \text{Full scale voltage} - \text{LSB}$$

$$= 10 - \frac{10}{2^8 - 1}$$

$$= 10 - \frac{10}{255} = 9.961 \text{ V}$$

End of Solution

124. Lead frequency compensation is a technique used to increase
(a) the phase margin (b) the gain
(c) the bandwidth (d) the slew rate

Ans. (a)

End of Solution

125. Which one of the following is not correct for the AAA instruction in 8086 microprocessors?
(a) It works only on the AL register.
(b) It updates AF and CF.
(c) It checks the result for correct unpacked BCD.
(d) It updates all the flags.

Ans. (d)

ASCII adjust (accumulator) after addition is used to convert result of addition of two unpacked BCD digits to a valued two digit BCD number.
AL of AX is default register to hold operand. Actually it adds 6 internally and converters the result two valid BCD.

$$\Sigma n = \frac{9}{+5}\ ;$$
$$(E)_H$$

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E is not BCD (0 to 9)
So add 6

$$6 = (20)_{10}$$
$$(20)_{10} = (14)_{16}$$

It affect carry flag and auxiliary carry flag. Hence it checks AF and CF.

End of Solution

126. Which one of the following filters is used to recover original signal from its sample ?
(a) Low pass filter (b) High pass filter
(c) Band pass filter (d) Band reject filter

Ans. **(a)**

End of Solution

127. In the first order low pass filter, which one of the following statements is not correct ?
(a) It has the maximum gain at frequency of 0 Hz.
(b) At higher cutoff frequency, the gain falls to 0.707 times the maximum gain.
(c) For frequency greater than higher cutoff frequency, the gain decreases at a constant rate of- 20 dB/decade.
(d) It has the maximum gain in stop band.

Ans. **(d)**

End of Solution

128. The quantization error is equivalent to
(a) internal noise generated within system.
(b) impulse noise.
(c) inter modulation noise as it produces harmonics.
(d) additive white noise as it alters the signal amplitude.

Ans. **(d)**
A common assumption for the analysis of quantization error is that it affects a signal processing system in a similar manner to that of an additive white noise. The additive noise model is commonly used for the analysis of quantization error effects in digital filtering.

End of Solution

129. A frequency division multiplexing system is used to multiplex 24 independent voice signals. Single sideband modulation is used for the transmission. Each voice signal is allotted a bandwidth of 4 kHz. What is the overall transmission bandwidth of the channel?
(a) 4 kHz (b) 6 kHz
(c) 24 kHz (d) 96 kHz

Ans. (d)

$$N = 24$$
$$\text{SSB B.W.} = \text{Message B.W.}$$
$$= 4 \text{ kHz}$$
$$\text{Transmission B.W.} = 24 \times 4 \text{ kHz}$$
$$= 96 \text{ kHz}$$

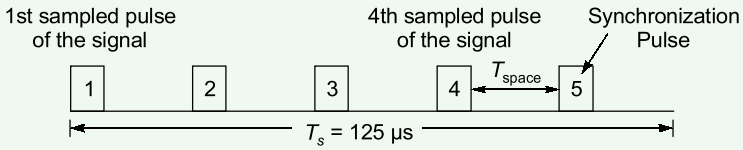
End of Solution

130. A Time Division Multiplexing system is used to multiplex four independent voice signals using pulse amplitude modulation. Each voice signal is sampled at the rate of 8 kHz. The system incorporates a synchronizing pulse train for its proper operation. What is the timing between the synchronizing pulse trains and the impulse trains used to sample the four voice signals?

(a) 5 μs (b) 10 μs
(c) 15 μs (d) 25 μs

Ans. (d)

$$\text{Sampling rate } (F_s) = 8 \text{ kHz}$$
$$\text{Frame time } (T_s) = \frac{1}{f_s} = \frac{1}{8 \text{ kHz}}$$
$$T_s = 125 \text{ μs}$$



$$5 \times T_{space} = 125 \text{ μs}$$
$$T_{space} = 25 \text{ μs}$$

End of Solution

131. Which one of the following statements is correct for full amplitude modulation?

(a) The spectrum consists of two side bands (one termed the upper side band and the other termed the lower side band).
(b) The spectrum consists of one sideband (termed the upper sideband).
(c) The spectrum consists of one sideband (termed the lower sideband).
(d) The spectrum consists of three sidebands (one termed the upper sideband, the second termed the lower sideband, and the third termed the lowest sideband).

Ans. (a)

End of Solution

132. The highest frequency component of a speech signal needed for telephonic communications is about 3.1 kHz. What is the suitable value for the sampling rate?

(a) 1 kHz (b) 2 kHz
(c) 4 kHz (d) 8 kHz

Ans. (d)

$$f_s \geq 2f_m$$
$$f_s \geq 2 \times 3.1k$$
$$f_s \geq 6.2 \text{ kHz}$$
$$f_s = 8 \text{ kHz}$$

End of Solution

133. Which one of the following is the advantage of FIR filter over IIR filter?

(a) FIR filter can have an exact linear phase.
(b) FIR filter is always unstable.
(c) For FIR filter, the design methods are non-linear.
(d) FIR filter cannot be realized efficiently in hardware.

Ans. (a)

End of Solution

134. Consider the following statements for a periodic signal :

1. Both the magnitude and phase spectra are line spectra.
2. For real-valued signals, the magnitude spectrum has even symmetry.
3. For real valued signals, the phase has odd symmetry.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1, 2 and 3
(c) 2 and 3 only (d) 1 and 3 only

Ans. (b)

End of Solution

135. Consider the following statements regarding power of a continuous-time and discrete-time signals :

1. Power is the time average of energy.
2. A signal with finite energy has zero power.
3. A signal with finite power has infinite energy.
4. All finite periodic signals are power signals.

Which of the above statements are correct?

(a) 1, 2, 3 and 4 (b) 1, 2 and 3 only
(c) 2, 3 and 4 only (d) 1 and 4 only

Ans. (a)

End of Solution

136. Which one of the following filters is used for reduction of power line harmonics, suppression of clutter from fixed objects in moving target indication radar?

(a) NOTCH filter
(b) IIR filter
(c) FIR filter
(d) COMB filter

Ans. (d)

End of Solution

137. For $z_1 = 2e^{j\pi/4}$ and $z_2 = 8e^{j\pi/3}$, the value of $\frac{z_1}{z_2^2}$ is

(a) $e^{-j\frac{5\pi}{12}}$
(b) $\frac{1}{8}e^{-j\frac{6\pi}{17}}$
(c) $\frac{1}{32}e^{-j\frac{5\pi}{12}}$
(d) $\frac{1}{14}e^{-j\frac{5\pi}{17}}$

Ans. (c)

$$\frac{z_1}{z_2^2} = \frac{2e^{j\pi/4}}{8^2 e^{2\pi j/3}} = \frac{1}{32}e^{-j5\pi/12}$$

End of Solution

138. The simplified value of $\int x^2 \cos ax\,dx$ is

(a) $\frac{1}{a^3}(2ax\cos ax - 2\sin ax + a^2x^2\sin ax)$
(b) $\frac{1}{a^2}(2ax\cos ax - 2\sin ax + a^2x\sin ax)$
(c) $\frac{1}{a}(2ax\cos ax - 2\sin ax + ax\sin ax)$
(d) $\frac{1}{a}(2ax\cos ax - 2\sin ax + a^2x^2\sin ax)$

Ans. (a)

$$\int x^2\cos ax\,dx = x^2\left(\frac{\sin ax}{a}\right) - 2x\left(\frac{-\cos ax}{a^2}\right) + 2\left(\frac{-\sin ax}{a^3}\right)$$

$$= \frac{1}{a^3}\left[a^2x^2\sin ax + 2ax\cos ax - 2\sin ax\right]$$

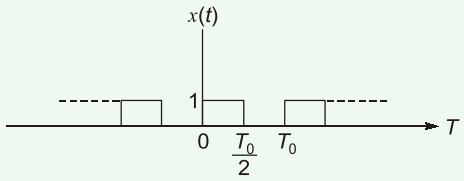
End of Solution

139. What is the total average power in the unit-amplitude square wave of period, T, and 50% duty cycle?

(a) 1.5 (b) 0.25

(c) 0.5 (d) 1

Ans. (c)



$$P = \frac{1}{2} = 0.5$$

End of Solution

140. For a system with unit impulse response $h[k] = (0.5)^k u[k]$, what is the zero state response $y[k]$ for the input $f[k] = (0.8)^k u[k]$?

(a) $y[k] = \left[-\frac{2}{3}(0.5)^k + \frac{7}{3}(0.6)^k\right]u[k]$ (b) $y[k] = \left[-\frac{5}{3}(0.5)^k + \frac{8}{3}(0.8)^k\right]u[k]$

(c) $y[k] = \left[-\frac{1}{3}(0.5)^k + \frac{2}{3}(0.8)^k\right]u[k]$ (d) $y[k] = \left[-(0.5)^k + (0.6)^k\right]u[k]$

Ans. (b)

$$y(k) = h(k) * f(k)$$
$$= (0.5)^k u(k) * (0.8)^k u(k)$$
$$y(z) = \left(\frac{1}{1-0.5z^{-1}}\right)\cdot\left(\frac{1}{1-0.8z^{-1}}\right)$$
$$= \frac{-5/3}{1-0.5z^{-1}} + \frac{8/3}{1-0.8z^{-1}}$$

By taking inverse, $y(k) = -\frac{5}{3}(0.5)^k u(k) + \frac{8}{3}(0.8)^k u(k)$

End of Solution

141. The value of $\int x^2 e^{ax} dx$ is

(a) $\frac{e^{ax}}{a}(a^2x^2 + 3ax - 2)$ (b) $\frac{e^{ax}}{a^4}(a^3x^2 - a^2x + 2ax + 1)$

(c) $\frac{e^{ax}}{a^3}(a^2x^2 - 2ax + 2)$ (d) $\frac{e^{ax}}{a^2}(a^3x^2 - 2a^2x + 4)$

Ans. (c)

$$= \frac{x^2e^{ax}}{a} - \int 2x \cdot \frac{e^{ax}}{a}dx$$

$$= \frac{x^2e^{ax}}{a} - 2\left[\frac{xe^{ax}}{a^2} - \int \frac{e^{ax}}{a^2}dx\right]$$

$$= \frac{x^2e^{ax}}{a} - \frac{2xe^{ax}}{a^2} + \frac{2e^{ax}}{a^3}$$

$$= \frac{e^{ax}}{a^3}\left[a^2x^2 - 2ax + 2\right]$$

End of Solution

142. What is the convolution $y[n] = x[n]*h[n]$: where $x[n] = \alpha^n u[n]$, $h[n] = \beta^n u[n]$, $\alpha \neq \beta$, $\alpha = 0.8$, $\beta = 0.9$?

(a) $y[n] = [9(0.9)^n - 8(0.8)^n]u[n]$ (b) $y[n] = [0.9(9)^n - 0.8(8)^n]u[n]$

(c) $y[n] = [0.3(9)^n - 0.4(8)^n]u[n]$ (d) $y[n] = [9(0.3)^n - 8(0.4)^n]u[n]$

Ans. (a)

$$y(n) = x(n) * h(n)$$

$$y(z) = X(z).H(z)$$

$$= \frac{1}{1-az^{-1}} \times \frac{1}{1-\beta z^{-1}}$$

$$= \frac{A}{1-az^{-1}} + \frac{B}{1-\beta z^{-1}}$$

$$= \frac{-8}{1-0.8z^{-1}} + \frac{9}{1-0.9z^{-1}}$$

$$\Rightarrow \quad y(n) = -8(0.8)^n u(n) + 9(0.9)^n u(n)$$

End of Solution

143. With one of the following is correct for parseval equality?

(a) $\int_{-\infty}^{+\infty} |x(t)|^2 dt = \frac{1}{2\pi}\int_{-\infty}^{+\infty} |X(j\omega)|^2 d\omega$ (b) $\int_{-\infty}^{+\infty} |x(t)|^2 dt = \frac{1}{2\pi}\int_{0}^{+\infty} |X(j\omega)|^{1/2} d\omega$

(c) $\int_{-\infty}^{+\infty} |x(t)|^2 dt = \frac{1}{\pi}\int_{0}^{+\infty} |X(j\omega)|^{1/2} d\omega$ (d) $\int_{-\infty}^{+\infty} |x(t)|^2 dt = \frac{4}{3\pi}\int_{-\infty}^{+\infty} |X(j\omega)|^2 d\omega$

Ans. (a)

End of Solution

144. For $x(t) = \sin(10\pi t)/\pi t$, what is the condition on the sampling interval T so that $x(t)$ is uniquely represented by the discrete-time sequence $x[n] = x(nT)$?

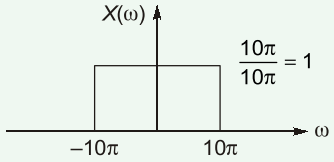
(a) $T < 1/10$ (b) $T < 1/5$

(c) $T > 1/5$ (d) $T > 1/10$

Ans. (a)

$$x(t) = \frac{\sin(10\pi t)}{\pi t} = 10\left(\frac{\sin(10\pi t)}{10\pi t}\right)$$

$$= 10\,\text{Sa}(10\pi t)$$



$$F_{ny} = 2f_m = 2 \times 5 = 10 \text{ Hz}$$

where F_{ny} is Nyquist rate,

$$T_s \le T_{ny} = \frac{1}{f_{ny}} = \frac{1}{10} = 0.1$$

$$T_s \le \frac{1}{10}$$

End of Solution

Directions : Each of the next six (6) items consists of two statements, one labelled as the 'Statement (I) and the other labelled as 'Statement (II)'. You are to examine these two statements carefully and select the answers to these items using the codes given below :

Codes :

(a) Both Statement (I) and Statement (II) is the correct explanation of Statement (I).

(b) Both Statement (I) and Statement (II) are individually true, but Statement (II) is not the correct explantion of Statement (I).

(c) Statement (I) is true, but Statement (II) is false.

(d) Statement (I) is false, but Statement (II) is true.

145. **Statement I :** Ferromagnetic properties are confined almost entirely to iron, nickel and cobalt and their alloys.

Statement II : By substituting the basic ferrite of magnetite with other divalent oxides, a wide range of ferrimagnetic compounds with useful properties can be produced, which have high electrical resistivity to minimise eddy currents at high frequencies.

Ans. (b)

End of Solution

146. **Statement I :** The inorganic materials are used to manufacture suspension insulators for high-voltage overhead lines and bushings on high-voltage transformers and switchgear.
Statement II : The ceramic and glass materials are formed into a series of flanged discs to decrease the creepage distance along the surface of the complete insulator.

Ans. (b)
Both given statements are correct but statement-II is not the reason of statement-I.

End of Solution

147. **Statement I :** In resonant circuits, the capacitor voltage or inductor current could be much lower than the source voltage or source current, and a large input signal can produce a small output signal when resonance appears in a circuit.
Statement II : In resonant circuits, the quality factor for a coil is defined as the ratio of the inductive reactance and the winding resistance, which is a dimensionless parameter.

Ans. (d)

End of Solution

148. **Statement I :** The pattern of the electric field lines strongly depends on the geometric arrangement of charge carriers and the field lines always enter or exit the charge carrier vertically.
Statement II : From the field pattern, a small distance between adjacent field lines (high field line density) ndicates low field strength.

Ans. (c)

End of Solution

149. **Statement I :** A strain gauge pressure sensor converts the physical quantity "pressure" into an electrical signal and electrical resistance of the strain gauge changes with the tensile strain.
Statement II : Bourdon tube pressure sensors work on the principle of change of any form of deformation, the cross-sectional tubing tends to recover its circular form under the action of pressure, which is used as mechanical pressure measuring instrument.

Ans. (b)

End of Solution

150. **Statement I :** Lightly doped n^- epitaxial layer is present in pn-junction diode.
Statement II : Power diodes have lightly doped n^- epitaxial layer which can absorb the depletion layer during reverse biased.

Ans. (a)

End of Solution

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