1. The important fact about the collector current is

(A) It is greater than emitter current

(B) It equal the base current divided by the current gain

(C) It is small

(D) It approximately equals the emitter current

Key: (D)

Exp: The emitter current of the BJT is given by

$I_E = I_C + I_B$

For a BJT with a large β value, the recombination of carriers at the base will be negligibly small. Hence, the base current will be $I_B << I_C$

So $I_E \approx I_C$

The collector current is approximately equal to the emitter current.

2. What is Shockley's equation of a semiconductor diode in the forward bias regions?

(A) $I_D = I_S\left(e^{V}D^{2/\eta V_T} - 1\right)$

(B) $I_D = I_S\left(e^{V_D/\eta V_T} - 1\right)$

(C) $I_D = I_S\left(e^{nV_D/\eta V_T} - 1\right)$

(D) $I_D = I_S\left(e^{V_T/\eta V_D} - 1\right)$

where I_S is reverse saturation current

V_D is applied forward-bias voltage across the diode

V_T is thermal voltage

n is an ideality factor

Key: (B)

Exp: For an abrupt pn junction diode, the diode current is modelled by William Shockley as

$$I_D = I_S\left[e^{\frac{V_D}{\eta V_T}} - 1\right]$$

Where I_D = Diode Current

I_S = Reverse Saturation Current

V_D = Potential applied across the junction

$V_T = \frac{KT}{2}$ thermal voltage

η = Ideality factor

3. The thermal voltage V_T of a semiconductor diode at 27°C temperature is nearly

(A) 17mV

(B) 20mV

(C) 23mV

(D) 26mV

Key: (D)

Exp: Thermal voltage,

$$V_T = \frac{KT}{q}$$

$T = 27 + 273 = 300$ kelvin

$$V_T = \frac{1.38\times10^{-23}\times300}{1.6\times10^{-19}}$$

$= 0.0259$ volt ≈ 26mV.

4. The disadvantages of atypical MOSFET as compared to BJT is

(A) Increased power-handling levels

(B) Reduced power-handling levels

(C) Increased voltage-handling levels

(D) Reduced voltage-handling levels

Key: (D)

Exp: The MOSFETs cannot be used for high voltage applications when compared to BJT due to the following reasons.

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1. High voltage causes damage of gate insulator of the MOSFET by Electrostatic Discharge (ESD).

2. When the supply voltage V_{DD} (hence V_{DS}) becomes very high, the MOSFET's threshold voltage decreases due to drain induced barrier lowering. This causes reliability issues.

3. At larger V_{DS}, hot electron effect causes electrons to enter inside the gate insulator and modifies threshold voltage. Hence the MOSFET becomes useless for proper operation.

5. Which one of the following conditions will be satisfied for an impedance matched system?

(A) The decibel power gain is equal to twice the decibel voltage gain

(B) The decibel power gain is equal to the decibel voltage gain

(C) The decibel power gain is half the decibel voltage gain

(D) The decibel power gain is equal to thrice the decibel voltage gain

Key: (A)

Exp: Power gain (dB)

$$=10\log\left[\frac{P_{out}}{P_{in}}\right]=10\log\left[\frac{\dfrac{\left(V_{out}^2\right)}{R_{out}}}{\dfrac{V_{in}^2}{R_{in}}}\right]$$

For impedance matched system $R_{out}=R_{in}$

Power gain (dB)

$$=10\log\left(\frac{V_{out}}{V_{in}}\right)^2=2\times10\log\left(\frac{V_{out}}{V_{in}}\right)$$

Power gain (dB) = 2 Voltage gain (dB).

6. For most FET configurations and for common-gate configurations, the input impedances are respectively

(A) High and high

(B) High and low

(C) Low and low

(D) Low and high

Key: (C)

Exp: For a common gate MOSFET amplifier the input resistance is given by

$$R_{in}=\frac{R_D+r_0}{1+g_m r_0}$$

Neglecting channel length modulation

$$R_{in}=\frac{1}{g_m}$$

Thus, the input impedance of the common gate amplifier is low provided g_m is large and the output resistance

$R_{out}=R_D$ which is also low.

7. The dB gain of cascaded systems is simply

(A) The square of the dB gains of each stage

(B) The sum of the dB gains of each stage

(C) The multiplication of the dB gains of each stage

(D) The division of the dB gains of each stage

Key: (B)

Exp: For n-stages of amplifiers

$$A_{net}=A_1,\ A_2\ \ ....A_n\ \text{(for cascaded system)}$$

$$\Rightarrow\left(20\log\left(A_{net}\right)\right)d_B$$

$$=20\log A_1+20\log A_2+..........+20\log A_n$$

$$\therefore\ \text{dB gain}=\text{dB gain}\ A_1$$

$$+\text{dB gain}\ A_2+.............+\text{dB gain of}\ A_n$$

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8. The Miller effect input capacitance C_{M_i} is

(A) $\left(1-A_V^2\right)C_f$

(B) $\left(1-A_V\right)C_f$

(C) $\left(1-C_f\right)A_V$

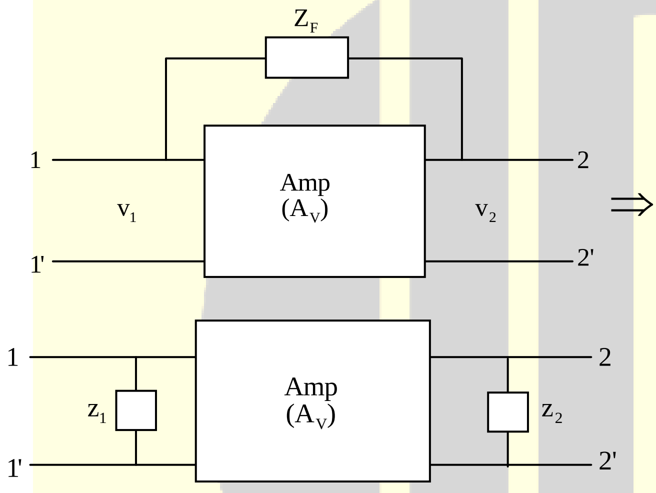
(D) $\left(1-C_f^2\right)A_V$

where C_f = feedback capacitance $A_V = \frac{V_o}{V_i}$

Key: (B)

Exp:

Miller's theorem



$$Z_1 = \frac{Z_F}{1-A_V} = \frac{1}{1-A_V} = \frac{1}{\left(1-A_V\right)C_F S}$$

$$C_{mi} = \left(1-A_V\right)C_F$$

9. For an op-amp having a slew rate of 2V/μs, if the input signal varies by 0.5V in 10μs, the maximum closed-loop voltage gain will be

(A) 50

(B) 40

(C) 22

(D) 20

Key: (B)

Exp: Let the input to an amplifier V_i

The output $V_o \approx A_V V_i$

The slew rate, $SR = \left.\frac{dv_o}{dt}\right|_{max}$

$$= A_V \left.\left(\frac{dv_i}{dt}\right)\right|_{max}$$

$$A_v = \frac{SR}{\left(\frac{dv_i}{dt}\right)} = \frac{2\times 10^6}{\left(\frac{0.5}{10\times 10^{-6}}\right)} = 40$$

10. A negative feedback amplifier where an input current controls an output voltage is called

(A) Current amplifier

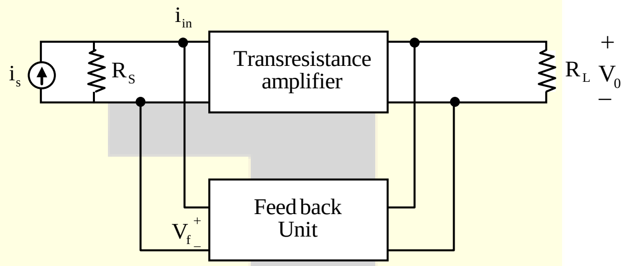
(B) Transconductance amplifier

(C) Transresistance amplifier

(D) Voltage amplifier

Key: (C)

Exp: For a transresistance amplifier the input is a current signal and the output is voltage signal.



11. In emergency lighting system, the component used for maintaining the charge on the battery is

(A) LED

(B) Shockley diode

(C) Thermistor

(D) SCR

Key: (C)

Exp: Thermistor is a key component in the charging systems for Lithium-Ion batteries used in emergency lighting system. The overheating of battery during charging cycle reduces the battery life. So thermistor based temperature sensors are used to sense the

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temperature of the battery and accordingly adjust the charging current for extending the life time of the batteries.

12. For RC phase shift oscillator using FET, the gain of the amplifier stage must be practically somewhat greater than

(A) 27
(B) 28
(C) 29
(D) 30

Key: (C)

Exp: For a RC phase shift oscillator made of Field Effect Transistor (FET),

The feedback factor,

$$-\beta = \frac{1}{1-5\propto^2 - j\left(6\propto - \propto^2\right)}$$

$$\propto = \frac{1}{\omega RC}$$

For the phase shift of 180° we have

$$\propto = \sqrt{6}$$

$$f = \frac{1}{2\pi\sqrt{6}RC}$$

At that frequency $|AB| \geq 1$ makes

$$A \geq 29, \text{ and } \beta = \frac{1}{29}$$

13. The time delay in a look-ahead carry adder is independent of

(A) Number of operands only
(B) Propagation delay only
(C) Number of bits in the operand only
(D) Bits in the operand, number of operands and propagation delay

Key: (C)

Exp: The time delay in look ahead carry adder is independent of number of bits in the operand only.

14. The time delay Δt introduced by a SISO shift register in digital signals is given by

(A) $N^2 \times \frac{1}{f_c}$

(B) $N^2 \times f_c$

(C) $\frac{f_c}{N}$

(D) $N \times \frac{1}{f_c}$

where N is the number of stages

f_c is the clock frequency

Key: (D)

Exp: Using SISO shift register, we can introduce time delay "Δt" in digital signals given by

$$\Delta t = N \times T = N \times \frac{1}{f_c}$$

Where, N = Number of stages

T = Time period of CLK pulse

f_c = CLK frequency

Note: The amount of delay can be controlled by the "f_c" or number of ffs in the shift register. Two options easily can be eliminated as they doesn't have unit of time.

15. An analog output voltage for the input 1001 to a 4 bit D/A converter for all possible inputs assuming the proportionality factor K=1 will be

(A) 9
(B) 6
(C) 3
(D) 1

Key: (A)

Exp: $V_o = K\left(\text{decimal equivalent}\right)$

$$= 1 \times \left(2^3 \times 1 + 0 \times 2^2 + 0 \times 2^1 + 2^0 \times 1\right)$$

$$= 1 \times (8+1) = 9.$$

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16. In microprocessor interface, the concept of detecting some error condition such as 'no match found' is called

(A) Syntax error

(B) Semantic error

(C) Logical error

(D) Error trapping

Key: (D)

Exp: In microprocessor a interface the concept of detecting some error condition such as "no match found" is called Error trapping.

17. The maximum number of input or output devices that can be connected to 8085 microprocessor are

(A) 8

(B) 16

(C) 40

(D) 256

Key: (D)

Exp: The maximum no. of Input or output device that can be connected to 8085 microprocessor is $2^8=256$.

With respect to each distinct port address we can connect a input /output device.

18. The contents of the accumulator and register C are 2EH and 6CH respectively. The instruction ADD C is used. The values of AC and P flags are

(A) 0 and 0

(B) 1 and 1

(C) 0 and 1

(D) 1 and 0

Key: (B)

Exp: $A=(2E)_{16}=(00101110)_2$

$C=(6C)_{16}=(01101100)$

$ADDC=(A)+(C)\rightarrow A$

$$\begin{array}{r} 00101110 \\ \underline{01101100} \\ \underline{10011010} \end{array}$$

From the result we can say

$[S=1],[Z=0],[AC=1],[P=1],[Y=0]$

19. When an information signal is multiplied by an auxiliary sinusoidal signal to translate its frequency, the modulation is called

(A) Phase modulation

(B) Frequency modulation

(C) Amplitude modulation

(D) Quadrature amplitude modulation

Key: (C)

Exp: $y(t)=m(t)\cos\omega_c t$

$$y(f)=\frac{m(f-f_c)+m(f+f_c)}{2}$$

Given the maximum value of the analog sample is to be represented with in 0.1% accuracy.

$$0.1\%\,Am\geq\frac{\Delta}{2}$$

$$\Delta=\frac{2A}{L};\qquad L=2^n$$

So, $2^n\geq1000$

$n\geq\log_2 1000$

$n\geq10.5$

$n=11$

20. The transmission power efficiency for a tone modulated signal with modulated index of 0.5 will be nearly

(A) 6.7%

(B) 11.1%

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(C) 16.7%

(D) 21.1%

Key: (B)

Exp: Transmission efficiency $= \frac{\mu^2}{2+\mu^2}$

Given $\mu = 0.5$

$$\eta = \frac{(0.5)^2}{2+(0.5)^2} = 0.111$$

$\eta = 11.1\%.$

21. For practical purposes, the signal to noise ratio for acceptable quality transmission of analog signals and digital signals respectively are

(A) 10-30 dB and 05-08 dB

(B) 40-60 dB and 10-12 dB

(C) 60-80 dB and 20-24 dB

(D) 70-90 dB and 30-36 dB

Key: (B)

22. The discrete samples of an analog signal are to be uniformly quantized for PCM system. If the maximum value of the analog sample is to be represented within 0.1% accuracy, then minimum number of binary digits required will be nearly

(A) 7

(B) 9

(C) 11

(D) 13

Key: (C)

23. A signal: $m(t) = 2\cos 60000\pi t + 4\cos 8000\pi t + 6\cos 10000\pi t$ is to be truthfully represented by its samples. The minimum sampling rate using band pass consideration will be

(A) 5,000 Hz

(B) 10,000 Hz

(C) 15,000 Hz

(D) 20,000 Hz

Key: (A)

Exp: $m(t) = 2\cos 6000\pi t + 4\cos 8000\pi t + 6\cos 10000\pi t$

$f_{mi} = 3\text{kHz}$, $f_2 = 4\text{kHz}$, $f_3 = 5\text{kHz}$

They have asked sampling rate using band pass consideration.

Hence, we cannot use concept of $f_s \geq 2f_{max}$

$$K = \frac{5}{3-2} = 2.5 \approx 2$$

(nearest digit not exceeding 2.5)

$$(f_s)_{min} = \frac{2f_{max}}{K} = \frac{2\times 5\text{kHz}}{2} = 5\text{kHz}$$

24. If 'N' signals are multiplexed using PAM band limited to f_M, the channel bandwidth need not be larger than

(A) $N.\frac{f_M}{2}$

(B) $N.f_M$

(C) $2N.f_M$

(D) $N^2.f_M$

Key: (B)

Exp: Number of signals = N

$R_S = \text{bit rate} = N.f_s$

$f_s = 2f_m$ (highest frequency)

Channel bandwidth $\geq \frac{R_b}{2}$

$\geq Nf_m$

Minimum bandwidth $= Nf_m$

Concentration $= 6.02\times 10^{23} \times \frac{1}{63.5} \times 8.4$

$= 7.96\times 10^{22}$ atoms / cm^3

Voice changes

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25. A linear discrete- time system is characterized by its response $h_k(n)=(n-k)u(n-k)$ to a delayed unit sample $\delta(n-k)$. The system will be

(A) Shift invariant
(B) Shift variant
(C) Scale invariant
(D) Scale variant

Key: (B)

26. Consider the analog signal
$x_a(t)=3\cos 100\pi t$
The minimum sampling rate F_S required to avoid aliasing will be

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

Key: (A)

Exp: $x_a(t) = 3\cos 100\pi f$

$(f_s)_{min} = 2f_{max}$ (to avoid aliasing)

$= 2\times 50 = 100\text{Hz}.$

27. The response of the system $y(n)=x(n)$ to the following input signal

$$x(n)=\begin{cases}|n|, & -3\le n\le 3\\ 0, & \text{otherwise}\end{cases}$$

(A) Is delayed from input
(B) Is exactly same as the input
(C) Leads the input
(D) Varies with signal

Key: (B)

Exp: As $y(n)=x(n)$, Hence response is exactly same as the input.

28. The complex exponential Fourier representation for the signal
$x(t)=\cos\omega_0 t$ is

(A) $\sum_{k=-\infty}^{\infty} c_k e^{-jk\omega_0 t}$
(B) $\sum_{k=-\infty}^{\infty} c_k e^{-j\omega_0 t}$
(C) $\sum_{k=-\infty}^{\infty} c_k e^{2jk\omega_0 t}$
(D) $\sum_{k=-\infty}^{\infty} c_k e^{jk\omega_0 t}$

Key: (D)

29. The continuous LTI system is described by

$$\frac{dy(t)}{dt}+2y(t)=x(t)$$

Using the Fourier transform, for $x(t)=e^{-t}u(t)$, the output will be

(A) $(e^{-t}-e^{2t})u(t)$
(B) $(e^{t}+e^{-2t})u(t)$
(C) $(e^{-t}-e^{-2t})u(t)$
(D) $(e^{t}+e^{2t})u(t)$

Key: (C)

Exp: $\frac{dy(t)}{dt}+2\,Y(t)=X(t)$

by fourier transform $(j\omega+2)\,Y(j\omega)=X(j\omega)$

$\frac{Y(j\omega)}{X(j\omega)}=\frac{1}{(j\omega+2)}$

If $X(t)=U(t)$, then $Y(j\omega)$

$=\frac{1}{(j\omega+2)}\cdot\frac{1}{(j\omega+1)}$

IFT $\Rightarrow Y(t)=\left(e^{-t}-e^{-2t}\right)U(t)$

30. The discrete Fourier series representation for the following sequence

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$x(n)=\cos\frac{n}{4}n$ is

(A) $\frac{1}{2}e^{j\Omega_0 n}+\frac{1}{2}e^{-j\Omega_0 n}$ and $\Omega_0=\frac{\pi}{8}$

(B) $\frac{1}{2}e^{-j\Omega_0 n}+\frac{1}{2}e^{-2j\Omega_0 n}$ and $\Omega_0=\frac{\pi}{4}$

(C) $\frac{1}{2}e^{-j\Omega_0 n}+\frac{1}{2}e^{-j\Omega_0 n}$ and $\Omega_0=\frac{\pi}{6}$

(D) $\frac{1}{2}e^{j\Omega_0 n}+\frac{1}{2}e^{j7\Omega_0 n}$ and $\Omega_0=\frac{\pi}{4}$

Key: (A)

Exp: $x(n)=\cos\left\{\frac{\pi}{4}n\right\}$

Discrete fourier series $x(m)=\sum_{k=\infty}^{\infty}cke^{jn\Omega_0 K}$

From given signal, $\Omega_0=\frac{\pi}{8}$ and

$C_1=\frac{1}{2}$ and $C(-1)=\frac{1}{2}$

$x(n)=\frac{1}{2}e^{j.\Omega_0 n}+\frac{1}{2}e^{-j\Omega_0 n}$ where $\Omega_0=\frac{\pi}{8}$.

31. Consideration the discrete-time sequence $x(n)=\cos\left(\frac{nx}{8}\right)$ When sampled at frequency $f_S=10kHz$, then f_0 the frequency of the sampled continuous time signal which produced this sequence will at least be

(A) 625 Hz

(B) 575 Hz

(C) 525 Hz

(D) 475 Hz

Key: (A)

Exp: Digital frequency, $W=\frac{2\pi f_0}{f_s}\Rightarrow\frac{\pi}{8}=\frac{2\pi f_0}{10k}$

$f_0=\frac{10k}{16}=625Hz$

32. How many bits are required in an A/D converter with a B+1 quantizer to get a signal-to-quantization noise ratio of at least 90 dB for a Gaussian signal with range of $\pm3\sigma_x$?

(A) B+1 = 12 bits

(B) B+1=14 bits

(C) B+1=15 bits

(D) B+1=16 bits

Key: (D)

Exp: Signal power $\sigma_x^2=$ variance

Noise power $=\frac{\Delta^2}{12}$

$\Delta=\frac{Am(P-P)}{2^n}$

$Am(p-p)=3\sigma_x-(-3\sigma_x)=6\sigma_x$

$SNR=\frac{S}{N_q}=\frac{2^{2n}}{3}$

SNR in (dB) $=6n-48dB\geq 90dB$

$n=16$ bits

$n=B+1$ bit quantizer

33. Let x(n) be a left-sided sequence that is equal to zero for $n>0$. If $X(z)=\frac{3z^{-1}+2z^{-2}}{3-z^{-1}+z^{-2}}$, then x(0) will be

(A) 0

(B) 2

(C) 3

(D) 4

Key: (B)

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Exp: $x(z)=\dfrac{3z^{-1}+2z^{-2}}{3-z^{-1}+z^{-2}}$ for signal is left sided

$$z^{-2}-z^{-1}+3\,\big)\;2z^{-2}+3z^{-1}\;\big(2+5z+....$$

$$\underline{2z^{-2}+2z^{-1}+6}$$

$$\underline{5z^{-1}-6}$$

Signal is left sided so $x(0)=2.$

34. The noise variance σ_ε^2 at the output of $H(z)=\dfrac{0.5z}{z-0.6}$ with respect to input will be nearly

(A) 40%

(B) 50%

(C) 60%

(D) 70%

Key: (A)

Exp: Given

$$H(z)=\frac{0.5z}{1-0.6z}=0.5\left[\frac{z}{1-0.6z}\right]$$

$$=0.5\left[\frac{1}{1-0.6z^{-1}}\right]$$

By Inverse z-transform

$$h(n)=0.5(0.6)^n$$

Let's take $S_x(f)=\dfrac{N_o}{2}$

$$S_y(f)=\left|H(\omega)\right|^2.\frac{N_o}{2}$$

Noise power at output

$$=\frac{N_o}{2}\int_{\infty}^{\infty}\left|H(f)\right|^2 df$$

$$=\frac{N_o}{2}\int_{\infty}^{\infty}\left|h(n)\right|^2 dx$$

$$=\frac{N_o}{2}\frac{0.25}{1-0.36}=\frac{N_o}{2}\frac{25}{64}$$

$$=\frac{N_o}{2}[0.39]$$

Output power = 40% of input power.

35. If the complex multiply operation takes 1μs, the time taken to compute 1024-point DFT directly will be nearly

(A) 3.45s

(B) 2.30s

(C) 1.05s

(D) 0.60s

Key: (C)

Exp: Number of complex multiplications required

Direct computation of FFT is

$N^2=1024\times1024=1048576$

Time taken each computation is 1 μs

So, $T=1.048\,\text{sec}=1.05\,\text{sec}$

36. Consider the following data to design a low pass filter

Cut-off frequency $\omega_c=\dfrac{\pi}{2}$,

Stop band ripple $\delta_s=0.002$,

Transition bandwidth no larger than 0.1π. Kaiser window parameters β and N respectively are

(A) 2.99 and 45

(B) 4.99 and 45

(C) 2.99 and 65

(D) 4.99 and 65

Key: (D)

Exp: $A=-20\log 5$

$P=+0.1102(A-8.7)$

$$N=\frac{A-8}{2.2852\pi b}+1$$

Using kaiser window

$A=54, B=4.992$

$N=65$

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37. A transfer function $G(s)=\frac{1-sT}{1+sT}$ has a phase angle of $\left(-2\tan^{-1}\omega T\right)$, which varies from $0°$ to $-180°$ as ω is increased from 0 to ∞. It is the transfer function for

(A) All pass system
(B) Low pass system
(C) High pass system
(D) Band pass system

Key: (A)

Exp: $|Gj\omega|=1$ for all frequency & and phase $0°$ to $-180°$

Hence it is all pass system.

38. The open-loop and closed-loop transfer functions of a system are respectively given by

$$G(s)=\frac{K}{j\omega\tau+1};\ (\text{open loop})$$

$$G(s)=\frac{\frac{K}{(1+K)}}{j\omega\tau_c+1};(\text{closed loop})$$

The ratio of the bandwidth of closed loop to open loop system is

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

Key: (B)

Exp: Gain of OLTF = K

Gain of CLTF= $\frac{K}{1+K}$

$B.W \propto \frac{1}{\text{Gain}}$

Hence $\frac{B.W_{(CLTF)}}{B.W_{(OLTF)}}=\frac{\text{Gain}_{(OLTF)}}{\text{Gain}_{(CLTF)}}=\frac{K}{\frac{K}{1+K}}=1+K$

39. The system sensitivity of open loop closed loop system are respectively

(A) 1 and $\frac{1}{1+GH}$
(B) $\frac{1}{1+GH}$ and 1
(C) $\frac{1}{GH}$ and 1
(D) 1 and $\frac{1}{GH}$

Key: (A)

Exp: Sensitivity of open loop system is

$$S_G^G=\frac{\frac{dG}{G}}{\frac{G}{G}}=1$$

Sensitivity of closed loop system is $\frac{1}{1+GH}$

40. The steady state error of a type-1 system unit step input is

(A) $\frac{1}{(1+K_p)}$
(B) 0
(C) ∞
(D) $\frac{1}{K_v}$

Key: (B)

Exp: e_{ss} (steady state error) for unit

Step input $=\frac{1}{1+\lim_{s\to 0}G(s)H(S)}$

If G(S) H(S) is type –1, then

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$$K_p = \lim_{s\to 0} G(S)H(S) = \infty$$

$$\therefore e_{ss} = \frac{1}{1+\infty} = 0$$

41. The direction of the net encirclements of the origin of Real-Imaginary plane in a Nyquist plot for the system to be stable is

(A) Clockwise of the origin

(B) Counter-Clockwise of the origin

(C) Left hand side s-plane

(D) Right hand side s-plane

Key: (B)

Exp: If Nyquist contour direction is clockwise, then Nyquist plot in counter – clockwise of the origin doesn't enclose any point inside. Hence, system will be stable.

42. A unity negative feedback control system has an open-loop transfer function as

$$G(s) = \frac{K(s+1)(s+2)}{(s+0.1)(s-1)}$$

The range of values of K for which the closed loop system is stable will be

(A) $0 < K < 0.3$

(B) $K > 0.3$

(C) $K > 3$

(D) $K < 0.3$

Key: (B)

Exp: $1 + G(S)H(S) = 0 \rightarrow$ characteristic equation

$$\Rightarrow (s+0.1)(s-1) + k(s+1)(s+2) = 0$$

$$\Rightarrow s^2(1+k) + s(3k-0.9) + (2k-0.1) = 0$$

For stability coefficient must be positive for second order system.

$1 + K > 0 \Rightarrow K > -1$

$3K - 0.9 > 0 \;\; K > 0.3 \rightarrow$ valid condition

$2K - 0.1 > 0 \;\; K > 0.05$

43. The lag system of a 'lag-lead compensator' has one pole and one zero. Then pole and zero are

(A) Real and pole is to the left of zero

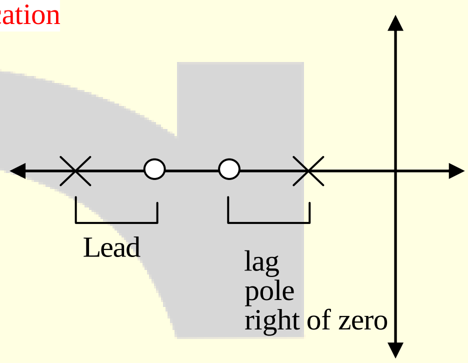
(B) Real and pole is to the right of zero

(C) Imaginary and pole is above zero

(D) Imaginary and pole is below zero

Key: (B)

Exp: Lag lead compensator pole – zero diagram location



44. A system with characteristic equation

$$F(s) = s^4 + 6s^3 + 23s^2 + 40s + 50$$

will have closed loop poles such that

(A) All poles lie in the left half of the s-plane and no pole lies on imaginary axis

(B) Two poles lie symmetrically on the imaginary axis of the s-plane

(C) All four poles lie on the imaginary axis of the s-plane

(D) All four poles lie in the right half of the s-plane

Key: (A)

Exp: Characteristic equation

$s^4+6s^3+23s^2+40s+50=0$

s^4	1	23	50
s^3	6	40	0
s^2	16.33	50	0
s^1	21.63	0	0
s^0	50		

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No sign changes occurs in the first column of RH table. Hence all poles lie in the left half of the s-plane and no pole lies on imaginary axis.

45. A unity feedback (negative) system has open loop transfer function

$$G(s)=\frac{K}{s(s+2)}$$

The closed loop system has a steady-state unit ramp error of 0.1. The value of gain K should be

(A) 20

(B) 30

(C) 40

(D) 50

Key: (A)

Exp: For ramp input

$$e_{ss}=\frac{A}{K_v}$$

$$K_v=\lim_{s\to 0} s\,G(s)\,H(s)=\frac{K}{s(s+2)}.1\times s=\frac{K}{2}$$

$$\Rightarrow e_{ss}=\frac{1}{K/2}=0.1\Rightarrow K=20$$

46. Transfer function of discrete time system derived from state model is given by

(A) $C(zI-A)^{-1}B+D$

(B) $C(zI-A)^{-1}D+B$

(C) $B(zI-A)^{-1}D+C$

(D) $D(zI-A)^{-1}B+C$

Key: (A)

Exp: $TF=C[zI-A]^{-1}B+D$

47. The closed-loop response of a system subjected to a unit step input is

$$c(t)=1+0.2e^{-60t}-1.2e^{-10t}$$

The expression for the closed loop transfer function is

(A) $\frac{100}{(s+60)(s+10)}$

(B) $\frac{600}{(s+60)(s+10)}$

(C) $\frac{60}{(s+60)(s+10)}$

(D) $\frac{10}{(s+60)(s+10)}$

Key: (B)

Exp: $C(t)=1+0.2e^{-60t}-1.2e^{-10t}$

$C(\infty)=1+0-0=1$

Now cross check from option, which has final value 1 that would be correct answer.

From option (B)

$$\lim_{s\to 0}\frac{s.600}{(s+60)(s+10)}\times\left\{\frac{1}{s}\Rightarrow \text{input}\right\}$$

$$\Rightarrow\frac{600}{60\times 10}=1.(\text{Hence B is correct})$$

48. If it is possible to transfer the system state $x(t_0)$ to any desired state x(t) in specified finite time by a control vector u(t), then the system is said to be

(A) Completely observable

(B) Completely state controllable

(C) Random state system

(D) Steady state controlled system

Key: (B)

Exp: If it is possible to transfer the system state x(to) to any desired state x(t) in specified finite time by control vector u(t), then the system is said to be completely state controllable.

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49. Consider the following statements regarding parallel connection of 3-phase transformers:

1. The secondaries of all transformers must have the same phase sequence.

2. The phase displacement between primary and secondary line voltages must be the same for all transformers which are to be operated in parallel.

3. The primaries of all transformers must have the same magnitude of line voltage.

Which of the above statements are correct ?

(A) 1, 2 and 3
(B) 1 and 3 only
(C) 1 and 2 only
(D) 2 and 3 only

Key: (A)

Exp: Conditions for parallel operation of 3-phase transformers:

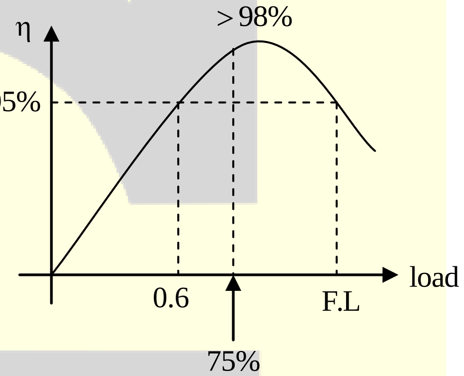
1. Phase sequence of two transformers must be same. (Hence statement-I is correct)
2. Phase displacement between primary and secondary line voltage of the two transformers must be same. (i.e. they must be of the same vector group). Hence Statement II is correct.
3. Instantaneous polarities of the two transformers being connected in parallel must be same and must have the same magnitude of line voltage. Hence statement III is also correct.

50. A 500 kVA transformer has an efficiency of 95% at full load and also at 60% of full load, both at upf. The efficiency η of the transformer at ¾th full load will be nearly

(A) 98%
(B) 95%
(C) 92%
(D) 87%

Key: (B and A)

Exp: If we go for calculations, we get answer as 95%. But according to variation of efficiency with respect to load current there will be a possibility of getting efficiency more than 95%. So, in this case option (A) will be the answer.



$$\eta_{FL(Upf)} = \frac{500\times1}{500\times1+W_{cu}+W_i} = 0.95$$

$$W_{cu}+W_i = 26.61\,kW$$

$$\eta_{60\%FL(Upf)} = \frac{300\times1}{300\times1+(0.6)^2W_{cu}+W_i} = 0.95$$

$$(0.6)^2W_{cu}+W_i = 15.78\,kW$$

$$0.36W_{cu}+W_i = 15.78\,kW$$

$$W_{cu}+W_i = 26.31$$

$$0.36W_{cu}+W_i = 15.78$$

$$0.64W_{cu} = 10.53$$

$$W_{cu} = \frac{10.53}{0.64} = 16.45\,kW$$

$$W_i = 26.31-16.45 = 9.86\,kW$$

$$\eta_{\frac{3}{4}FL(Upf)} = \frac{375\times1}{375\times1+(0.75)^2\times16.45+9.86}$$

$$= \frac{375}{394}\times100 = 95\%$$

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51. What is the condition of retrogressive winding in dc machines?

(A) $Y_b > Y_f$

(B) $Y_b < Y_f$

(C) $Y_b = Y_f$

(D) $Y_b = 0.5Y_f$

Key: (B)

Exp: For retrogressive winding $y_b < y_f$

For progressive winding $y_b > y_f$

52. What is the useful flux per pole on no load of a 250V, 6-pole shunt motor having a wave connected armature winding with 110 turns, armature resistance of 0.2Ω and armature current 13.3A at no load speed of 908 rpm?

(A) 12.4 mWb

(B) 22.6 mWb

(C) 24.8 mWb

(D) 49.5 mWb

Key: (C)

Exp: Given,

$250V = V_t, P = 6, z = 110 \times 2 = 220,$

$R_a = 0.2\Omega$

$I_a = 13.3A, N_{NL} = 908\,rpm,$

$A = 2 \ (\because \text{wave windings})$

$$E_a = \frac{P\phi NZ}{60A} = (250 - 13.3 \times 0.2)$$

$$= \frac{6 \times \phi \times 908 \times 220}{60 \times 2}$$

$$= \phi = 0.02476\text{Wb or } 24.8\text{mWb}$$

53. The cross-magnetizing effect of the armature reaction can be reduce dby

(A) Making pole shoes flat faced

(B) Making the main field ampere-turns larger compared to the armature-ampere turns

(C) Increasing the flux density under one half of the pole

(D) Keeping the direction of rotation of generator in the same direction as motor

Key: (B)

Exp: The cross-magnetizing effect of the armature reaction can be reduced by making the main field ampere-turns larger compared to the armature ampere-turns such that the main field mmf exerts predominant control over the air-gap flux. This is achieved by introducing saturation in the teeth and pole-shoe.

54. A 500kW, 500V, 10-pole, dc generator has a lap wound armature with 800 conductors. If the pole face covers 75% of pole pitch, the number of pole-face conductors in each pole of a compensating winding will be

(A) 12

(B) 10

(C) 8

(D) 6

Key: (D)

Exp: No. of compensating winding

$$\text{Conductor/pole, } Z_C = \frac{Z}{PA}\left\{\frac{\text{Pole arc}}{\text{Pole pitch}}\right\};$$

Where $P = $ No. of pole,

$A = $ No. of parallel path

$$= \frac{800}{10 \times 10} \times 0.75 = 8 \times 0.75 = 6$$

55. Cogging in an induction motor is caused

(A) If the number of stator slots are unequal to number of rotor slots

(B) If the number of stator slots are an integral multiple of rotor slots

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(C) If the motor is running at fraction of its rated speed

(D) Due to 5^{th} harmonic

Key: (B)

Exp: Cogging is known as Magnetic locking, and magnetic locking occurs if the no. of stator slots are an integral multiple of rotor slots.

56. A 500 hp, 6-pole, 3-phase, 440V, 50Hz induction motor has a speed of 950 rpm on full-load. The full load slip and the number of cycles the rotor voltage makes per minute will be respectively

(A) 10% and 150

(B) 10% and 125

(C) 5% and 150

(D) 5% and 125

Key: (C)

Exp: Full load slip =

$$\frac{N_s - N_r}{N_s} = \frac{1000-950}{1000} = 0.05 = 5\%$$

The no. of cycles the rotor voltage makes/minute=

$0.05 \times 50 \times 60 = 150$cycle/minute.

57. Effective armature resistance R_a(eff) of a synchronous machine is

(A) $\dfrac{\text{Short circuit load loss (per phase)}}{(\text{Short circuit armature current})^2}$

(B) $\dfrac{\text{Short circuit load loss (per phase)}}{(\text{Short circuit armature current})}$

(C) $\dfrac{\text{Total short circuit load loss}}{\text{Short circuit armature current}}$

(D) $\dfrac{\text{Total short circuit load loss}}{\text{Short circuit load current}}$

Key: (A)

Exp: Effective armature resistance $R_a(\text{eff})$ of a synchronous machine is

$$= \frac{\text{Short circuit load loss}(3.\phi)}{3\left(I_{SC}^2\right)}$$

$$= \frac{\text{Short circuit load loss(per phase)}}{\left(I_{SC}\right)^2}$$

Where I_{SC} = short circuit armature current

58. A 3-phase synchronous motor has 12-poles and operates from 440V, 50 Hz supply. If it takes a line current of 100 A at 0.8 power factor leading, its speed and torque are nearly

(A) 500 rpm and 1165 N-m

(B) 1000 rpm and 2330 N-m

(C) 500 rpm and 2330 N-m

(D) 1000 rpm and 1165 N-m

Key: (A)

Exp: As we know, synchronous motor speed is always synchronous speed

$$N_S = \frac{120 \times 50}{12} = 500\text{rpm}$$

$$\text{Power input} = \sqrt{3} \times 440 \times 100 \times 0.8$$

$$= 60968.188\text{W}$$

$$P = T \times \omega_S$$

$$T = \frac{P}{\omega_S} = \frac{60968.188 \times 60}{2\pi \times 500}$$

$$= 1164.4066 \text{ N-m} \approx 1165 \text{N-m}$$

59. Which of the following are the advantages of using a stepper motor?

(A) Compatibility with transformers and sensors needed for position sensing

(B) Compatibility with digital systems and sensors are not required for position and speed sensing

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(C) Resonance effect often exhibited at low speeds and decreasing torque with increasing speed

(D) Easy to operate at high speeds and compatible with analog systems

Key: (B)

Exp: Stepper motors are compatible with digital system due to discrete control available.

60. The disadvantage of hunting in synchronous machines is

(A) Fault occurs in the supply system

(B) Causes sudden change in inertia

(C) Causes large mechanical stresses and fatigue in the rotor shaft

(D) Causes harmonics

Key: (C)

The phenomenon of oscillation of the rotor about its final equilibrium position is called Hunting. On the sudden application of load, the rotor search for its new equilibrium position and this process is known as Hunting. The Hunting process occurs in a synchronous motor as well as in synchronous generators if an abrupt change in load occurs.

Effect of Hunting

The various effects of hunting are as follows:-

It can lead to loss of synchronism.

It can cause variations of the supply voltage producing undesirable lamp flicker.

The possibility of Resonance condition increases. If the frequency of the torque component becomes equal to that of the transient oscillations of the synchronous machine, resonance may take place.

Large mechanical stresses may develop in the rotor shaft.

The machine losses increases and the temperature of the machine rises.

61. What are the values of k for which the system of equations

$$(3k-8)x+3y+3z=0$$
$$3x+(3k-8)y+3z=0$$
$$3x+3y+(3k-8)z=0$$

has a non-trivial solution?

(A) $k=\frac{2}{3},\frac{11}{3},\frac{10}{3}$

(B) $k=\frac{2}{3},\frac{10}{3},\frac{11}{3}$

(C) $k=\frac{11}{3},\frac{11}{3},\frac{11}{3}$

(D) $k=\frac{2}{3},\frac{11}{3},\frac{11}{3}$

Key: (D)

Exp: $\begin{vmatrix} 3k-8 & 3 & 3 \\ 3 & 3k-8 & 3 \\ 3 & 3 & 3k-8 \end{vmatrix}=0$

$$\Rightarrow \begin{vmatrix} 3k-2 & 3 & 3 \\ 3k-2 & 3k-8 & 3 \\ 3k-2 & 3 & 3k-8 \end{vmatrix}=0$$

$[\text{By applying } C_1 \to C_1+C_2+C_3]$

$R_2 \to R_2-R_1; R_3 \to R_3-R_1$; we have

$$\Rightarrow \begin{vmatrix} 3k-2 & 3 & 3 \\ 0 & 3k-11 & 0 \\ 0 & 0 & 3k-11 \end{vmatrix}=0$$

$$\Rightarrow (3k-2)\left[(3k-11)(3k-11)\right]=0$$

$[\text{Expanded along } C_1]$

$$\Rightarrow (3k-2)=0; 3k-11=0; 3k-11=0$$

$$\Rightarrow k=\frac{2}{3}; k=\frac{11}{3}; k=\frac{11}{3}$$

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62. If $A=\begin{bmatrix}2+i & 3 & -1+3i\\ -5 & i & 4-2i\end{bmatrix}$ then AA* will be

(where, A* is the conjugate transpose of A)

(A) Unitary matrix

(B) Orthogonal matrix

(C) Hermitian matrix

(D) Skew Hermitian matrix

Key: (C)

Exp: $AA^{*}=\begin{bmatrix}2+i & 3 & -1+3i\\ -5 & i & 4-2i\end{bmatrix}\begin{bmatrix}2-i & -5\\ 3 & -i\\ -1-3i & 4+2i\end{bmatrix}$

$=\begin{bmatrix}5+9+10 & -20+2i\\ -20-2i & 25+1+20\end{bmatrix}$

$=\begin{bmatrix}24 & -20+2i\\ -20-2i & 46\end{bmatrix},$

which is Hermitian matrix

$\left[\because A^{\theta}=A\right]$

63. If $y=2x^3-3x^2+3x-10$, the value of $\Delta^3 y$ will be

(where, Δ is forward differences operator)

(A) 10

(B) 11

(C) 12

(D) 13

Key: (C)

Exp: Given $y=2x^3-3x^2+3x-10=f(x)$

$\Rightarrow \Delta y=f(x+1)-f(x)$

$=\left[2(x+1)^3-3(x+1)^2+3(x+1)-10\right]$

$-\left[2x^3-3x^2+3x-10\right]$

$\Delta y=2\left[x^3+1+3x^2+3x\right]-3\left[x^2+1+2x\right]$

$+3x+3-10-2x^3+3x^2-3x+10$

$=2x^3+2+6x^2+6x-3x^2-3$

$-6x+3x-7-2x^3+3x^2-3x+10$

$=6x^2+2$

Similarly;

$\Delta^2 y=\left[6(x+1)^2+2\right]-\left[6x^2+2\right]$

$=6\left[x^2+1+2x\right]+2-6x^2-2$

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

Now $\Delta^3 y=12(x+1)+6-[12x+6]$

$=12x+12+6-12x-6=12$

$\Delta^3 y=12$

64. The solution of the differential equation

$x^2\dfrac{d^2y}{dx^2}-x\dfrac{dy}{dx}+y=\log x$ is

(A) $y=(c_1+c_2x)\log x+2\log x+3$

(B) $y=(c_1+c_2x^2)\log x+\log x+2$

(C) $y=(c_1+c_2x)\log x+\log x+2$

(D) $y=(c_1+c_2\log x)x+\log x+2$

Key: (D)

Exp: $(x^2D^2-xD+1)y=\log x$

$\Rightarrow\left[\theta(\theta-1)-\theta+1\right]y=z;$

where $\theta=\dfrac{d}{dz}$ and $z=\log x.$

$\theta(\theta-1)-\theta+1=0$

$\Rightarrow \theta^2-2\theta+1=0$

$\Rightarrow(\theta-1)^2=0\Rightarrow\theta=1,1$

$y_C=e^z\left[c_1+c_2z\right]$

$y_p=\dfrac{1}{\theta^2-2\theta+1}z$

$\Rightarrow y_p=\left[1+(\theta^2-2\theta)\right]^{-1}[z]$

$\Rightarrow y_p=\left[1-(\theta^2-2\theta)\right][z]=z+2(1)$

$\Rightarrow y_p=z+2$

$\therefore\ y=e^z\left[c_1+c_2z\right]+z+2$

$y=x\left[c_1+c_2\log x\right]+\log x+2$

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65. The area between the parabolas

$y^2 = 4ax$ and $x^2 = 4ay$ is

(A) $\frac{2}{3}a^2$

(B) $\frac{14}{3}a^2$

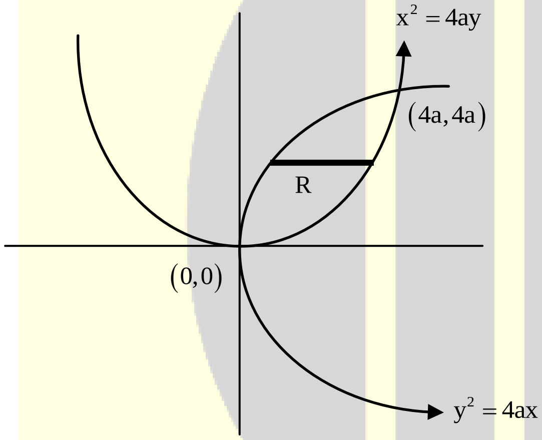
(C) $\frac{16}{3}a^2$

(D) $\frac{17}{3}a^2$

Key: (C)

Exp: Area between the parabolas,

$$A = \iint dx\,dy = \int_{y=ox=\frac{y^2}{4a}}^{4a} \int^{2\sqrt{ay}} dx\,dy = \int_{y=0}^{4a} [x]_{\frac{y^2}{4a}}^{2\sqrt{ay}}.dy$$



$\{y^2 = 4ax \Rightarrow \frac{y^2}{x} = 4a$

$x^2 = 4ay \Rightarrow \frac{x^2}{y} = 4a$

$\therefore \quad \frac{y^2}{x} = \frac{x^2}{y}$

$y^3 = x^3$

$y = x$

$\therefore \quad y^2 = 4ax$

$x^2 = 4ax$

$\Rightarrow x(x-4a) = 0 \Rightarrow x = 0;\ x = 4a$

$y = 0 \quad y = 4a\}$

$$= \int_{y=0}^{4a} \left[2\sqrt{ay} - \frac{y^2}{4a}\right] dy$$

$$= \frac{\left[2\sqrt{a}\left[\frac{y^{3/2}}{3/2}\right] - \frac{1}{4a}\left[\frac{y^3}{3}\right]\right]}{4a}$$

$$= \frac{4\sqrt{a}}{3}\left[(4a)^{3/2}\right] - \frac{1}{12a}\left[64a^3\right]^{y=0}$$

$$= \sqrt{\frac{4^5}{3}a^2} - \frac{16}{3}a^2$$

$$= \frac{32}{3}a^2 - \frac{16}{3}a^2 = \frac{16}{3}a^2$$

66. The volume of the solid surrounded by the surface

$\left(\frac{x}{a}\right)^{2/3} + \left(\frac{y}{b}\right)^{2/3} + \left(\frac{z}{c}\right)^{2/3} = 1$ is

(A) $\frac{4\pi abc}{35}$

(B) $\frac{abc}{35}$

(C) $\frac{2\pi abc}{35}$

(D) $\frac{\pi abc}{35}$

Key: (A)

Exp: $\left(\frac{x}{a}\right)^{2/3} + \left(\frac{y}{b}\right)^{2/3} + \left(\frac{z}{c}\right)^{2/3} = 1 \quad \ldots(1)$

Let $\left[\left(\frac{x}{a}\right)^{1/3}\right]^2 + \left[\left[\frac{y}{b}\right]^{1/3}\right]^2 + \left[\left[\frac{z}{c}\right]^{1/3}\right]^2 = 1$

$\left(\frac{x}{a}\right)^{1/3} = u \Rightarrow \frac{x}{a} = u^3;$

$\left(\frac{y}{b}\right)^{1/3} = v \Rightarrow \frac{y}{b} = v^3;$

$\left(\frac{z}{c}\right)^{1/3} = w \Rightarrow \frac{z}{c} = w^3$

$\Rightarrow dx = 3au^2du$

$dy = 3bv^2dv$

$dz = 3cw^2dw$

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The equation (1) of solid becomes

$u^2+v^2+w^2=1[\text{sphere}]$.

$$v=\iiint_v dxdydz=\iiint 27abc\,u^2v^2w^2 du dv\,dw$$

$$=27abc\iiint u^2v^2w^2 du\,dv\,dw \quad ..(I)$$

By taking spherical coordinates,

$u=r\sin\theta\cos\phi,\ v=r\sin\theta\sin\phi,\ \omega=r\cos\theta$

$du\,dv\,dw=r^2\sin\theta\,dr\,d\theta\,d\phi$

Now (I) becomes

$$v=27abc\int_{r=0}^{1}\int_{\theta=0}^{\pi}\int_{\phi=0}^{2\pi}\begin{pmatrix}r^2\sin^2\theta\cos^2\phi.\\ r^2\sin^2\theta\sin^2\phi.\\ r^2\cos^2\theta\, r^2\sin\theta\end{pmatrix}dr\,d\theta\,d\phi$$

$$v=27abc\int_{r=0}^{1}r^8dr\int_{\theta=0}^{\pi}\sin^5\theta\cos^2\theta\,d\theta\int_{\phi=0}^{2\pi}\sin^2\phi\cos^2\phi\,d\phi$$

$$v=27abc\int_{r=0}^{1}r^8dr\left[2\times\int_0^{\pi/2}\sin^5\theta.\cos^2\theta d\theta\right]\left[2\times2\times\int_0^{\pi/2}\sin^2\phi\cos^2\phi d\phi\right]$$

$$=27\times8\times abc\left[\frac{r^9}{9}\right]_0^1\times\left[\frac{(5-1)(5-3)(2-1)}{7\times(7-2)(7-4)(7-6)}\right]\left[\frac{(2-1)(2-1)}{4\times(4-2)}\right]\times\frac{\pi}{2}$$

$$=27\times8\times abc\left[\frac{1}{9}\right]\times\frac{4\times2\times1}{7\times5\times3\times1}\times\frac{1\times1}{4\times2}\times\frac{\pi}{2}$$

$$=\frac{4\pi abc}{35}$$

67. The solution of the partial differential equation

$x^2\frac{\partial z}{\partial x}+y^2\frac{\partial z}{\partial y}=(x+y)z$ is

(A) $f\left(\frac{1}{x}-\frac{1}{y},\frac{xy}{z}\right)=0$

(B) $f\left(\frac{1}{xy},\frac{xy}{z}\right)=0$

(C) $f\left(\frac{1}{x}-\frac{1}{y},xyz\right)=0$

(D) $f\left(\frac{1}{x}+\frac{1}{y}+\frac{1}{z},\frac{xy}{z}\right)=0$

Key: (A)

Exp: Let $P=\frac{\partial z}{\partial x},q=\frac{\partial z}{\partial y}$

$$\therefore\quad x^2p+y^2q=(x+y)z \quad \ldots(1)$$

Lagrange's equations corresponding to equation (1) are

$$\frac{dx}{x^2}=\frac{dy}{y^2}=\frac{dz}{(x+y)z} \quad \ldots(1)$$

$$\therefore\quad \frac{dx}{x^2}=\frac{dy}{y^2}\Rightarrow\int\frac{1}{x^2}dx=\int\frac{1}{y^2}dy$$

$$\Rightarrow\frac{-1}{x}=\frac{-1}{y}+c_1$$

$$\Rightarrow\frac{1}{x}-\frac{1}{y}=c_1 \quad \ldots(2)$$

By using Lagrange multipliers $\frac{-z}{x},\frac{-z}{y}$ and 1, then (1) becomes

$$\frac{\left(-\frac{z}{x}\right)dx-\left(\frac{z}{y}\right)dy+1.dz}{x^2\left(\frac{-z}{x}\right)+y^2\left(\frac{-z}{y}\right)+xz+yz}$$

$$=\frac{\left(\frac{-z}{x}\right)dx-\left(\frac{z}{y}\right)dy+dz}{-zx-zy+zx+zy}$$

$$=\frac{\left(\frac{-z}{x}\right)dx-\left(\frac{z}{y}\right)dy+dz}{0}$$

$$\Rightarrow\left(\frac{-z}{x}\right)dx-\left(\frac{z}{y}\right)dy=-dz$$

$$\Rightarrow\frac{1}{x}dx+\frac{1}{y}dy=\frac{1}{z}dz$$

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$\Rightarrow \ell nx + \ell ny = \ell nz + \ell nc_2$

$(\because$ By integrating on both sides$)$

$\Rightarrow \ell nxy = \ell nzc_2$

$\Rightarrow xy = zc_2$

$\Rightarrow c_2 = \frac{xy}{z}$ ...(3)

$\therefore$ The required solution of given partial D.E is

$f(u,v) = 0 \Rightarrow f\left(\frac{1}{x} - \frac{1}{y}, \frac{xy}{z}\right) = 0;$

$[\because$ from (2) and $(3)]$

Where $u = \frac{1}{x} - \frac{1}{y}; v = \frac{xy}{z}$

68. The complex number $\left(\frac{2+i}{3-i}\right)^2$ is

(A) $\frac{1}{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$

(B) $\frac{1}{2}\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right)$

(C) $\frac{1}{2}(\cos\pi + i\sin\pi)$

(D) $\frac{1}{2}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

Key: (B)

Exp: $\left(\frac{2+i}{3-i}\right)^2 = \left[\frac{(2+i)(3+i)}{9+1}\right]^2 = \left[\frac{5+5i}{10}\right]^2$

$= \frac{25}{100}(1+i)^2 = \frac{1}{4}[2i] = \frac{i}{2}$

$\left(\frac{2+i}{3-i}\right)^2 = \frac{i}{2} = \frac{1}{2}\left[e^{i\left[\frac{\pi}{2}\right]}\right] = \frac{1}{2}\left[\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right]$

69. If n is a positive integer then,

$\left(\sqrt{3}+i\right)^n + \left(\sqrt{3}-i\right)^n$ is

(A) $2^n \sin\frac{n\pi}{6}$

(B) $2^n \cos\frac{n\pi}{6}$

(C) $2^{n+1}\cos\frac{n\pi}{6}$

(D) $2^{n+1}\sin\frac{n\pi}{6}$

Key: (C)

Exp: $\left(\sqrt{3}+1\right)^n + \left(\sqrt{3}-i\right)^n = \left[2e^{i(\pi/6)}\right]^n + \left[2e^{i(-\pi/6)}\right]^n;$

Since polar force of $\sqrt{3}+i = 2e^{i\pi/6}$ and

Polar form of $\sqrt{3}-i = 2e^{i(-\pi/6)}$

$\left(\sqrt{3}+i\right)^n + \left(\sqrt{3}-i\right)^n$

$= 2^n e^{i(n\pi/6)} + 2^n e^{i(-n\pi/6)}$

$= 2^n \left[\cos\left(\frac{n\pi}{6}\right) + i\sin\left(\frac{n\pi}{6}\right) + \cos\left(\frac{n\pi}{6}\right) - i\sin\left(\frac{n\pi}{6}\right)\right]$

$= 2^n\left[2\cos\left(\frac{n\pi}{6}\right)\right] = 2^{n+1}.\cos\left(\frac{n\pi}{6}\right)$

70. The nature of singularity of function $f(z) = \frac{1}{\cos z - \sin z}$ at $z = \frac{\pi}{4}$ is

(A) Removable singularity

(B) Isolated singularity

(C) Simple pole

(D) Essential singularity

Key: (C)

Exp: Method-I:

At $z = \frac{\pi}{4}; \cos z - \sin z = 0$

But

$(\cos z - \sin z)' = -\sin z - \cos z = \frac{-1}{\sqrt{2}} - \frac{1}{\sqrt{2}}$

$= \frac{-2}{\sqrt{2}} = -\sqrt{2} \neq 0$

$z = \frac{\pi}{4}$ is a simple zero of $(\cos z - \sin z)$

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Given function $f(z) = \frac{1}{\cos z - \sin z}$

$\therefore \quad z = \frac{\pi}{4}$ is a simple pole of f(z);

Since at $z = \frac{\pi}{4}$; numerator function $\neq 0$

Method 2:

In case of pole of order '1'

$$\lim_{z \to \pi/4} \left(z - \frac{\pi}{4}\right) \frac{1}{(\cos z - \sin z)} \left(\frac{0}{0}\right)$$

$$\lim_{z \to \pi/4} \frac{1}{-\sin z - \cos z} = \frac{-1}{\sqrt{2}} \neq 0$$

$\therefore \quad z = \frac{\pi}{4}$ is a simple pole.

Similarly in case of pole of order 'n';

$$\lim_{z \to a} \left[(z-a)^n \times f(z)\right] \neq 0,$$

Then z = a is a pole of order 'n'.

71. If X is a discrete random variable that follows Binomial distribution, then which one of the following response relations is correct?

(A) $P(r+1) = \frac{n-r}{r+1} P(r)$

(B) $P(r+1) = \frac{p}{q} P(r)$

(C) $P(r+1) = \frac{n+r}{r+1} \frac{p}{q} P(r)$

(D) $P(r+1) = \frac{n-r}{r+1} \frac{p}{q} P(r)$

Key: (D)

Exp: From Binomial distribution, we have

$$P(x = r) = P(r) = nc_r p^r q^{n-r}$$

$$P(x = r+1) = P(r+1) = nc_{r+1}.p^{r+1} q^{n-(r+1)}$$

$$= nc_{r+1}.p^r.pq^{n-r} q^{-1}$$

$$\therefore \quad P(r) = n_{c_r} p^r q^{n-r}$$

$$= \frac{n!}{r!(n-r)!} p^r q^{n-r}$$

$$= \frac{n!}{r!(n-r)(n-r-1)!} p^r q^{n-r}$$

$$\Rightarrow p(r)[n-r] = \frac{n!}{r!(n-r-1)!} p^r q^{n-r} \quad \ldots(1)$$

$$p(r+1) = n_{c_{r+1}} p^r q^{n-r} pq^{-1}$$

$$= \frac{n!}{(r+1)![n-(r+1)]!} p^r q^{n-r} pq^{-1}$$

$$= \frac{n!}{(r+1)r!(n-r-1)!} p^r q^{n-r} \left(\frac{p}{q}\right)$$

$$\Rightarrow \frac{q}{p} p(r+1)(r+1) = \frac{n!}{r!(n-r-1)!} p^r q^{n-r}$$

$\therefore$ From (1) and (2);

$$p(r)(n-r) = \frac{q}{p} p(r+1)(r+1)$$

$$\Rightarrow p(r+1) = \frac{(n-r)p}{(r+1)q}.p(r)$$

72. If the probability that an individual suffers a bad reaction from a certain infection is 0.001, what is the probability that out of 2000 individuals, more than 2 individuals will suffer a bad reaction?

(A) $\frac{1}{2} - \frac{5}{e^2}$

(B) $1.2 - \frac{5}{e^2}$

(C) $1 - \frac{5}{e^2}$

(D) $\frac{5}{e^2}$

Key: (C)

Exp: Let A be the event that an individual suffers a bad reaction

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Given, $p(A) = 0.001 = \frac{1}{1000}$

Total numbers of individuals = n = 2000

$\therefore \quad np = 2000 \times \frac{1}{1000} = 2 = \lambda.[\text{Average}]$

$P[x > 2] = ?$

$x \rightarrow$ number of individuals suffer a bad reaction

$$p[x > 2] = 1 - p(x \le 2)$$
$$= 1 - [p(0) + p(1) + p(2)]$$
$(\because$ from poisson distribution$)$
$$= 1 - \left[e^{-\lambda}\left[1 + \lambda + \frac{\lambda^2}{2!}\right]\right]$$
$$= 1 - e^{-2}\left(1 + 2 + \frac{4}{2}\right) \qquad [\because \lambda = 2]$$
$$= 1 - e^{-2}.(5) = 1 - \frac{5}{e^2}$$

73. Materials in which the atomic order extends uninterrupted over the entirely of the specimen; under some circumstances, they may have flat faces and regular geometric shapes, are called
(A) Anisotropy
(B) Crystallography
(C) Single crystals
(D) Crystal system

Key: (C)

74. Which material possesses the following properties?
- Shining white colour with luster
- Soft, malleable and can be drawn into wires
- Poor in conductivity and tensile, strength
- Used in making alloys with lead and copper
- Used for fuses and cable sheathing

(A) Silver
(B) Tin
(C) Nickel
(D) Aluminium

Key: (C)

75. The saturation magnetization for Fe_3O_4, given that each cubic unit cell contains $8Fe^{2+}$ and $16Fe^{3+}$ ions, where Bohr magneton is 9.274×10^{-24} A.m^2 and that the unit cell edge length is 0.839 nm, will be
(A) 1.25×10^5 A/m
(B) 5×10^5 A/m
(C) 10×10^5 A/m
(D) 20×10^5 A/m

Key: (B)

Exp: Given data

Bohr magnetron $= 9.27 \times 10^{-24}\,\text{A.m}^2\,(\mu_\beta)$

Unit cell edge length $= 0.839 \times 10^{-9}$ m.

Magnetic moment per Fe^{2+} ion = 4 Bohr magneton.

Number of Fe^{2+} ions per unit cell = 8.

$\therefore$ The saturation magnetization

$$M_s = N_{fe^{2+}} \times 4 \times \mu B$$
$$= \frac{8}{(6.839 \times 10^{-9})^3} \times 4 \times 9.27 \times 10^{-24}$$
$$= 5.0 \times 10^5 \text{ A/m.}$$

76. Consider the following applications of the materials:
- Bismutch strontium calcium copper oxide used as a high temperature superconductor
- Boron carbide used in helicopter and tank armour

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- Uranium oxide used as fuel in nuclear reactors
- Bricks used for construction

The materials used in these applications can be classified as

(A) Ceramic
(B) Constantan
(C) Manganin
(D) Tantalum

Key: (A)

77. The saturation flux density for Nickel having density of 8.90 g/cm^3, atomic number 58.71 and net magnetic moment per atom of 0.6 Bohr magnetons is nearly

(A) 0.82 tesla
(B) 0.76 tesla
(C) 0.64 tesla
(D) 0.52 tesla

Key: (C)

Exp: Given,

Ni(Net magnetic moment per atom)

$= 0.6$ Bohr magnetron.

$\mu_B = 9.27\times10^{-24}\ A-m^2, \mu_0 = 4\pi\times10^{-7}\ \mu/M.$

Density $= 8.90\times10^6\ g/m^3\ (\rho_{Ni})$

$$N_{Ni} = \frac{\rho_{Ni}N_A}{A_{Ni}} = \frac{8.90\times16^6\times6.023\times10^{23}}{58.71}$$

$= 9.12\times10^{28}$

$M_s = 0.6\,\mu_B N_{Ni} = 0.6\times9.27\times10^{-24}\times9.12\times10^{28}$

$= 5.1\times10^5\ A/m.$

$B_s = \mu_B M_S = \left(4\pi\times10^{-7}\right)\times\left(5.1\times10^5\right) = 0.64$

78. The temperature at which iron ceases to be ferromagnetic and becomes paramagnetic is

(A) Curie-Weiss point
(B) Thermo-magnetic point
(C) Ferro-paramagnetic point
(D) Curie point

Key: (D)

Exp: The temperature at which Iron ceases to be ferromagnetic and becomes paramagnetic is curie point.

79. Fick's laws refer to

(A) Finding whether a semiconductor is n or p type
(B) Diffusion
(C) Crystal imperfections
(D) Electrical breakdown

Key: (B)

80. A magnetic field applied perpendicular to the direction of motion of a charged particle exerts a force on the particle perpendicular to both the magnetic field and the direction of motion of the particle. This phenomenon results in

(A) Flux effect
(B) Hall Effect
(C) Magnetic field effect
(D) Field effect

Key: (B)

81. An electric kettle is marked 500W, 230V and is found to take 15 minutes to bring 1 kg of water at 15°C to 100°C. If the specific heat of water is 4200 J/kg/°C, the heat efficiency of the kettle will be

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(A) 87.3%

(B) 83.6%

(C) 79.3%

(D) 75.6%

Key: (C)

Exp: $\text{Heat output} = \frac{\text{Mass of water} \times C_V \times \Delta T}{t\,(\text{in sec})}.$

$\Delta T = 100 - 15° = 85°C.$

$\text{Heat output} = \frac{1 \times 4200 \times 85}{15 \times 60}$

$= 396.67\,J/sec. = 396.66\,W$

$\text{Heat efficiency}\,(\eta) = \frac{\text{heat output}}{\text{heat input}} \times 100$

$= \frac{396.66}{500} \times 100 = 79.33\%$

82. With reference to nano materials, the prefix nano stands for

(A) Nano centimeter

(B) Nanometer

(C) Nano micrometer

(D) Nano millimeter

Key: (B)

Exp: Nanomaterials are characterized by at least 1-dimension in the Nanometer range.

83. Consider the following applications:

- High temperature heat engines
- Nuclear fusion reactors
- Chemical processing industry
- Aeronautical and space industry

Which one of the following materials will be used for these applications?

(A) Zirconia

(B) Alumina

(C) Ceramic

(D) Silicon carbide

Key: (D)

Exp: Silicon carbide used for

1. High temperature heat engines
2. Nuclear fusion reactors
3. Chemical processing industry
4. Aeronautical and space industry

84. The machine used for the preparation of nano particles of alumina is

(A) Attrition mill

(B) Grinding machine

(C) Vending machine

(D) Welding machine

Key: (A)

85. If the voltage across an element in a circuit is linearly proportional to the current through it, then it is a

(A) Capacitor

(B) Transformer

(C) Resistor

(D) Inductor

Key: (C)

Exp: $V = IR\,(\text{only possible resistor})$

$V \propto R$

86. Thevenins's equivalent circuit consists of

(A) Current source and series impedance

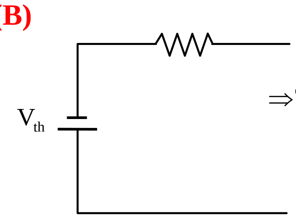
(B) Voltage source and series impedance

(C) Voltage source and shunt impedance

(D) Current source and shunt impedance

Key: (B)

Exp:



⇒Thevenin's eqivalent circuit

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87. When the voltage sources are replaced with short circuits and current sources are replaced with open circuits, leaving dependent sources in the circuit, the theorem applied is

(A) Superposition
(B) Thevenin
(C) Norton
(D) Millman

Key: (B&C)

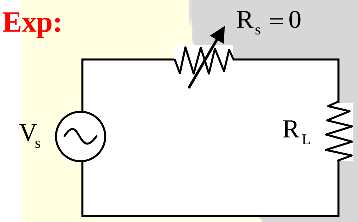
Exp: Question is ambiguous. As whatever mentioned in the question. it holds good for thevenin's as well as Norton's theorems.

88. The maximum power is delivered from a source to a load when the source resistance is

(A) Greater than the held load resistance
(B) Equal to zero
(C) Less than the load resistance
(D) Equal to the load resistance

Key: (B)

Exp:



89. A network delivers maximum power to the load resistance when it is

(A) Greater than Norton's equivalent resistance of the network
(B) Equal to Thevenin's equivalent resistance of the network
(C) Less than source resistance
(D) Less than Norton's equivalent resistance of the network

Key: (B)

Exp: Condition of maximum power transfer to the load

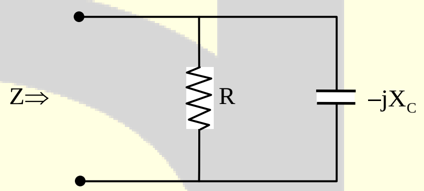
$R_{th} = R_L$

90. The impedance of a parallel circuit is $(10 - j30)\Omega$ at 1 MHz. The values of circuit elements will be

(A) 10Ω and 6.4 mH
(B) 100Ω and 4.7 nF
(C) 10Ω and 4.7 mH
(D) 100Ω and 6.4 nF

Key: (B)

Exp: Given $Z = (10 - j30)\Omega$



$y = \frac{1}{z},$

$y = \frac{10 + j30}{1000} \Rightarrow \frac{1}{R} + \frac{1}{-jXc}$

$\Rightarrow R = \frac{1000}{10} = 100\Omega,\ WC = \frac{3}{100}$

$\Rightarrow C = \frac{3}{100\times10^6 \times 2\pi} = 4.77\text{nF}$

91. Consider the following statements for a large national interconnected grid:

1. Better load frequency control
2. Same total installed capacity can meet lower demands
3. Better hydro/thermal/nuclear/ renewable co-ordination and energy conservation

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

Key: (D)

Exp: For a large National interconnected grid:

1. Requires better load frequency control.

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2. Same total installed capacity can meet lower demands in large national interconnected grid.
3. It is better for hydro/thermal/nuclear / renewable co-ordination and energy conservation.

92. A single-phase transformer is rated 110/440V, 2.5 kVA. Leakage reactance measured from the low-tension side is 0.06Ω. The per unit leakage reactance will be

(A) 0.0062/unit

(B) 0.0124/unit

(C) 0.0496/unit

(D) 0.1983/unit

Key: (B)

Exp: The per unit leakage reactance =

$$\frac{\text{Actual leakage reactance}}{\text{Base impedance}}$$

$$= \frac{0.06}{\frac{(110)^2}{2500}} = 0.0124 / \text{unit}$$

93. A concentric cable has a conductor diameter of 1 cm and an insulation thickness of 1.5cm. When the cable is subjected to a test pressure of 33 kV, the maximum field strength will be nearly

(A) 41,000 V

(B) 43,200 V

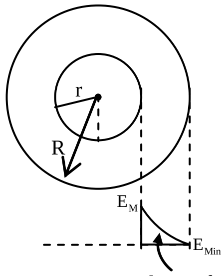
(C) 45,400 V

(D) 47, 600 V

Key: (C)

Exp: Given

$$r = 0.5\text{cm} (\because d = 1\text{cm})$$
$$R = 0.5\text{cm} + 1.5\text{cm}$$
$$(\because R = r + \text{thickness of insulation})$$
$$R = 2.0\text{cm}$$



Electric field strength variation

Maximum field strength is given as

$$E_{max} = \frac{V}{r\ell n(R/r)} = \frac{33000}{0.5\ell n\, 4}$$
$$= 47608.93V \approx 47600V.$$

94. Radio influence voltage (RIV) generated on a transmission line conductor surface is not affected by

(A) System voltage

(B) Corona discharges on the conductors

(C) Rain

(D) Nearby radio receivers

Key: (D)

Exp: Radio influence voltage depends on:

→ Operating system voltage

→ Corona discharge

→ Surface irregularity

→ Atmospheric condition (rain, dust etc)

Hence, option (A), (B) & (C) is not possible.

95. Consider the following properties regarding insulation for cables:

1. A low specific resistance

2. High temperature withstand

3. High dielectric strength

Which of the above properties of insulation are correct while using cables?

(A) 1 and 2 only

(B) 1 and 3 only

(C) 2 and 3 only

(D) 1, 2 and 3

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Key: (C)

Exp: The insulation of cables should have high specific resistance to limit the discharging current. Hence statement 1 is wrong.

96. Which one of the following faults occurs more frequently in a power system?

(A) Grounded star-delta

(B) Double line faults

(C) LLG faults

(D) Single line-to grounded (LG) faults

Key: (D)

Exp: Frequency of occurrence of various type of faults in decreasing order

LG > LL > LLG > LLL

LG ↓ Highest occurrence frequency; LLL ↓ Lowest frequency

97. The maximum permissible time of de-energization of the faulty circuit is dependent on

(A) Voltage of the system

(B) The number of conductors involved

(C) Load carried by the faculty circuit

(D) Fault current and its duration

Key: (D)

Exp: The maximum permissible time of de-energization of the faulty circuit is dependent on fault current & its duration

Permissible time = f(fault current, duration of persistency)

98. Which one of the following is used for communication with the aim of achieving high figure of merit in HVDC circuit breakers?

(A) Oil interrupter

(B) Air interrupter

(C) Vacuum interrupter

(D) SF_6 interrupter

Key: (C)

Exp: Vacuum interrupter is used for communication with the aim of achieving high figure of merit in HVDC circuit breakers

99. Which of the following buses are used to form bus admittance matrix for load flow analysis?

1. Load bus

2. Generator bus

3. Slack bus

(A) 1 and 2 only

(B) 1 and 3 only

(C) 2 and 3 only

(D) 1, 2 and 3

Key: (D)

Exp: Y_{bus} is constructed using all buses. (i.e. load bus, generator bus & slack bus).

100. In a 3-phase, 60 Hz, 500 MVA, 15kV, 32-pole hydroelectric generating unit, the values of ω_{syn} and ω_{msyn} will be nearly

(A) 754 rad/s and 47.6 rad/s

(B) 377 rad/s and 46.7 rad/s

(C) 377 rad/s and 23.6 rad/s

(D) 754 rad/s and 23.6 rad/s

Key: (C)

Exp: Given data, 60Hz, 500MVA, 15KV, 32 pole hydroelectric generating unit.

$$W_{syn}\left(\text{electrical}\right) = 2\pi f = 2\pi \times 60$$

$$= 120 \times 3.14 \simeq 377\,\text{rad/sec}$$

$$W_{msyn}\left(\text{mechanical}\right)$$

$$= \frac{2\pi N}{60} = \frac{2\pi \times 120 \times f}{60P} = \frac{4\pi f}{P}$$

$$\frac{4\pi \times 60}{35} == 23.56\ \text{rad/sec}$$

Hence C is correct.

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101. The methods adopted for improving the steady state stability of power system are

1. Quick response excitation system

2. Higher excitation voltages

3. Maximum power transfer by use of series capacitor or reactor

(A) 1 and 2 only

(B) 1 and 3 only

(C) 2 and 3 only

(D) 1, 2 and 3

Key: (C)

Exp: Quick response excitation system improves transient stability not steady state stability.

$\uparrow P_{max} \propto \text{Excitation} \uparrow \rightarrow$ Statement 2 is correct

$\uparrow P_{max} \propto \dfrac{1}{(X_L - X_C \uparrow)\downarrow} \rightarrow$ Statement 3 is correct

102. The HVDC system uses

(A) Rectifier station at sending end and inverter station at receiving end

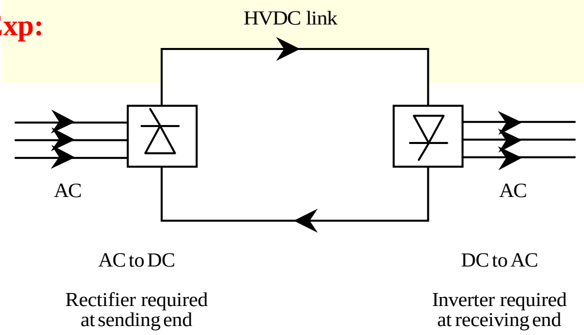
(B) Inverter station at sending as well as at the receiving end

(C) Rectifier station at sending end as well as at the receiving end

(D) Inverter station at sending end and rectifier station at receiving end

Key: (A)

Exp:



103. Which one of the following is not required for power diode?

(A) High speed operation

(B) Fast communication

(C) Small recovery time

(D) Low on-state voltage drop

Key: (B)

Exp: For power diode, high speed operation, small recovery time and low-on state voltage drop required but not fast communication

104. The reverse recovery time of a diode is $t_{rr} = 3\,\mu s$ and the rate of fall of the diode current is $\dfrac{di}{dt} = 30\ A/\mu s$. The storage charge Q_{RR} and the peak inverse current I_{RR} will be respectively

(A) 135μC and 90A

(B) 270μC and 90A

(C) 270μC and 60 A

(D) 135μC and 60 A

Key: (A)

Exp: $I_{RR} = \left(\dfrac{di}{dt}\right).t_{rr} = (30A)\times 10^{6} \times 3\times 10^{-6} = 90A$

Stored charge $= Q_{rr} = \dfrac{1}{2}\dfrac{di}{dt}t_{rr}^{2} = \dfrac{1}{2}\times 30\times 9$

$= 15\times 9 = 135\mu c$

Hence (A) is correct.

105. The $i_g - V_g$ characteristics of a thyristor is a straight line passing through origin with a gradient of 2.5×10^{3}. If $P_g = 0.015$ watt, the value of gate voltage will be nearly

(A) 5.0V

(B) 6.1V

(C) 7.5V

(D) 8.5V

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Key: (B)

Exp: Given

$$\frac{V_g}{I_g} = 2.5\times10^3, \text{ or } V_g = 2500 I_g$$

$$P_g = V_g I_g = (2500 I_g) I_g^2$$

$$I_g^2 = \frac{0.015}{2500} \Rightarrow I_g = \sqrt{\frac{0.015}{2500}} = 2.449\times10^{-3}/m$$

$$\therefore V_g = 2500\times2.449\times10^{-3}$$

$$= 6.123V \text{ (gate voltage)}$$

106. A single-phase 220V, 1kW heater is connected to half wave controlled rectifier and is fed from a 220V, 50 Hz ac supply. When the firing angle $\alpha = 90°$, the power absorbed by the heater will be nearly

(A) 1000W

(B) 750W

(C) 500W

(D) 250 W,

Key: (D)

Exp: Heater rating 1kW at 220V

$$\therefore R = \frac{V^2}{P} = \frac{220\times220}{1000} = \frac{22\times22}{10}\Omega$$

Power delivered to the load

$$= \frac{1}{R}\left(\frac{V_M}{\sqrt{2}\pi}\left[\frac{\pi}{2}\right]^{1/2}\right)^2 \quad (\text{for } \alpha = 90°)$$

$$= \frac{\left(\frac{220\sqrt{2}}{\sqrt{2}\pi}\left(\frac{\pi}{2}\right)^{1/2}\right)^2}{R} = \frac{220\times220\times2\times}{4\pi R}\frac{\pi}{2}$$

$$= \frac{220\times220\times10}{4\times22\times22} = \frac{1000}{4} = 250W$$

107. When we compare the half bridge converter and full bridge converter

1. The maximum collector current of a full bridge is only double that of the half bridge.

2. Full bridge uses 4-power switches instead of 2, as in the double bridge.

3. Output power of a full bridge is twice that of a half bridge with the same input voltage and current.

Which of the above statements are correct?

(A) 1, 2 and 3

(B) 1 and 2 only

(C) 1 and 3 only

(D) 2 and 3 only

Key: (D)

108. A single-phase fully controlled bridge converter is connected with RLE load where $R = 5\Omega, L = 4\text{ mH and } E = 50\text{ V}$. This converter circuit is supplied form 220 V, 50 Hz ac supply. When the firing angle is 60°, the average value of the load current will be nearly

(A) 12.2A

(B) 9.8A

(C) 6.4 A

(D) 4.2 A

Key: (B)

Exp: Assuming load current is constant

$$\Rightarrow I_o = \frac{V_o - E}{R} = \frac{\frac{2V_m}{\pi}\cos\alpha - E}{R}$$

$$= \frac{\frac{2\times220\times\sqrt{2}}{\pi}\cos 60° - 50}{5} = 9.806A$$

109. Consider the following statements regarding ac drives:

1. For the same kW rating, ac motors are 20% to 40% light weight as compared to dc motors.

2. The ac motors are more expensive as compared to same kW rating dc motors.

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3. The ac motors have low maintenance as compared to dc motors.

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

Key: (C)

Exp: The ac motors are less expensive as compared to same kw rating dc motors. Hence statement 2 is wrong.

110. A 3-phase induction motor drives a blower where load torque is directly proportional to speed squared. If the motor operates at 1450 rpm, the maximum current in terms of rated current will be nearly

(A) 2.2
(B) 3.4
(C) 4.6
(D) 6.8

Key: (A)

Exp: For $N = 1450$ rpm,

$$s = \frac{1500 - 1450}{1500} \Rightarrow S = 0.033$$

The slip at which T_2 is maximum for blower type load $\left(T_L \propto \omega^2\right)$ is $S = \frac{1}{3}$

$$\frac{I_2 \max}{I_2(\text{rated})} = \frac{\sqrt{\frac{1}{3}} \times \frac{2}{3}}{\sqrt{0.033 \times (1 - 0.033)}}$$

$$\Rightarrow (I_2)_{max} = 2.2 I_{2rated}$$

111. Consider the following statements:

1. SMPS generates both the electromagnetic and radio frequency interference due to high switching frequency.
2. SMPS has high ripple in output voltage and its regulation is poor.
3. The output voltage of SMPS is less sensitive with respect to input voltage variation.

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

Key: (D)

Exp: 1. SMPS generates both the electromagnetic and radio frequency interference due to high switching frequency.

2. The SMPS has higher output ripple and its regulation is worse.
3. SMPS also cause harmonic distortion.

Hence statement 1, 2 and 3 are correct.
Statements 1 and 2 are drawbacks of SMPS.
Statement 3 is advantage of SMPS

112. Consider the following features with respect to the flyback converters:

1. It is used mostly in application below 100W.
2. It is widely used for high-output voltage.
3. It has low cost and is simple.

Which of the above statements are correct?

(A) 1, 2 and 3
(B) 1 and 2 only
(C) 1 and 3 only
(D) 2 and 3 only

Key: (C)

Exp: Flyback converters $\rightarrow$ low power rating
$\rightarrow$ low voltage rating

Hence statement 2 is wrong $\rightarrow$ Low cost and simple

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113. Consider the following statements regarding the function of dc-dc converter in a dc motor:

1. It acts as a regenerative brake.

2. It controls the speed of motor.

3. It controls the armature voltage of a dc motor.

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

Key: (D)

Exp: DC-DC converter can be used for

→ regenerative braking

→ speed control of motor

→ Control of armature voltage

114. The power supplies which are used extensively in industrial applications are required to meet

1. Isolation between the source and the load

2. High conversion efficiency

3. Low power density for reduction of size and weight

4. Controlled direction of power flow

Which of the above specifications are correct?

(A) 1, 2 and 3 only

(B) 1, 3 and 4 only

(C) 1, 2 and 4 only

(D) 2, 3 and 4 only

Key: (C)

Exp: Statement 3 is wrong. High power density for reduction of size and weight.

Directions:

Each of the next ***6 (10)*** *items consists of two statements, one labelled as the 'Statement (I)' and the other 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) are individually true 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 explanation of Statement (I)

(C) Statement (I) is true but Statement (II) is false

(D) Statement (I) is false but Statement (II) is true

115. Statement I: Soft iron does not retain magnetism permanently.

Statement II: Soft iron has no retentivity.

Key: (C)

Exp: Soft magnetic materials can be easily magnetized and demagnetized. Soft magnetic material follow rapid switching of magnetization to the applied AC field. It has low retentivity & coercivity. Hence statement II is incorrect.

116. Statement I: Reaction turbines are generally used for sites with high head and low flow.

Statement II: Kaplan and Francis turbines are reaction turbines.

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Key: (D)

Exp: Reaction turbines are generally used for sites low head and high flow. Hence statement I is correct.

117. Statement I: One can formulate problems more efficiently in a high-level language and need not have a precise knowledge of the architecture of the computer.

Statement II: High level languages permit programmers to describe tasks in a form which is problem oriented than computer oriented.

Key: (A)

118. Statement I: Sign magnitude representation is generally used in implementing the integer portion of the ALU.

Statement II: In sign magnitude representation there are two representations of 0.

Key: (D)

119. Statement I: When a non-linear resistor, in series with a linear resistor, both being non-inductive, is connected to a voltage source, the current in the circuit cannot be determined by using ohm's law.

Statement II: If the current-voltage characteristic of the non-linear resistor is known, the current-voltage characteristic of the series circuit can be obtained by graphical solutions.

Key: (B)

120. Statement I: Soft magnetic materials, both metallic and ceramic are used for making transformers core, whereas, hard magnetic materials both metallic and ceramic are used for making permanent magnets.

Statement II: Magnetic materials, both metallic and ceramic are classified as soft or hard according to the magnetic hysteresis loop being narrow or broad.

Key: (A)

Exp: Soft-magnetic material: These materials can be easily magnetized and demagnetized and follow rapid switching of magnetization to the applied AC field. The hysteresis loop is narrow and hence used in transformer core.

Example fe – Ni alloy
ferrites etc.

Hard magnetic material: These materials are difficult to demagnetize. They retain their magnetization even after the removal of field. These are also known as permanent magnet material.

Hence statement-I is correct & statement-II is correct explanation.

121. The defining equations for V_1 and V_2 analyzing a two-port network in terms of its impedance parameters are respectively

(A) $Z_{12}I_1 + Z_{12}I_2$ and $Z_{21}I_1 + Z_{21}I_2$

(B) $Z_{11}I_1 + Z_{12}I_{12}$ and $Z_{21}I_1 + Z_{22}I_2$

(C) $Z_{21}I_1 + Z_{21}I_2$ and $Z_{12}I_1 + Z_{12}I_2$

(D) $Z_{12}I_1 + Z_{12}I_2$ and $Z_{22}I_1 + Z_{22}I_2$

Key: (B)

Exp: Impedance parameters equation, written as

$$V_1 = Z_{11}I_1 + Z_{12}I_2 \qquad ...(1)$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2 \qquad ...(2)$$

Hence (B)

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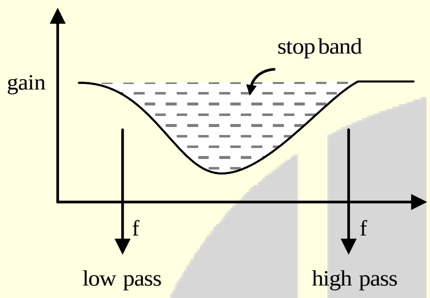
122. A filter that allows high and low frequencies to pass but attenuates any signal with a frequency between two corner frequencies is a

(A) Notch filter
(B) Band pass filter
(C) Band stop filter
(D) Multiband filter

Key: (C)

Exp:



Hence it is Band stop filter

123. When a number of two-port networks are cascaded then

(A) z-parameters are added up
(B) y-parameters are added up
(C) h-parameters are multiplied
(D) ABCD-parameters are multiplied

Key: (D)

Exp: For cascaded Network, (ABCD) – parameters are multiplied.

124. A 3-phase star-connected 1000 volt alternator supplies power to a 500 kW delta-connected induction motor. If the motor power factor is 0.8 lagging and its efficiency 0.9, then the current in each alternator and motor phase respectively are nearly

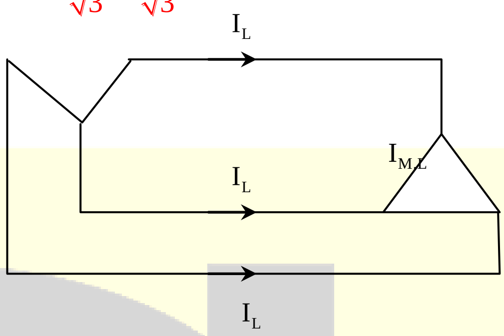
(A) 321 A and 231.5A
(B) 401 A and 231.5 A
(C) 321 A and 185.4 A
(D) 401 A and 185.4 A

Key: (B)

Exp: $I_L = \dfrac{500\times 10^3}{\sqrt{3}\times 1000\times 0.8\times 0.9} = 400.937A$

$I_L\,(\text{in alternator}) = 401A$

$I_M = \dfrac{I_L}{\sqrt{3}} = \dfrac{401}{\sqrt{3}} = 231.5A$



125. Consider the following statements:

1. Mutual inductance describes the voltage induced at the ends of a coil due to the magnetic field generated by a second coil.

2. The dot convention allows a sign to be assigned to the voltage induced due to mutual inductance term.

3. The coupling coefficient is given by $k = \dfrac{M}{\sqrt{L_1 + L_2}}$..

Which of the above statements are correct?

(A) 1, 2 and 3
(B) 1 and 3 only
(C) 1 and 2 only
(D) 2 and 3 only

Key: (C)

Exp: Statement 3 is wrong

Coupling coefficient is given by

$K = \dfrac{M}{\sqrt{L_1 L_2}}$

126. Consider the following statements:

1. The rules for series and parallel combinations of capacitors are opposite to those for resistors.

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2. The rules for series and parallel combinations of inductors are same as those for resistors.
3. An inductor is a short circuit to dc currents.

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

Key: (D)

127. The standard resistor is a coil of wire of some alloy having the properties of

(A) Low electrical resistivity and high temperature coefficient of resistance
(B) High electrical resistivity and high temperature coefficient of resistance
(C) Low electrical resistivity and low temperature coefficient of resistance
(D) High electrical resistivity and low temperature coefficient of resistance

Key: (D)

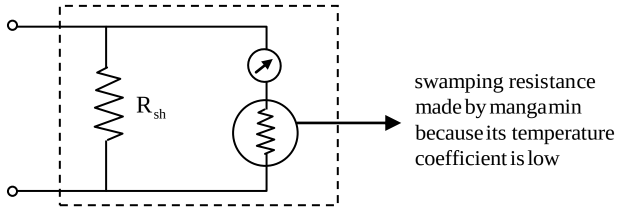
Exp: Standard resistor must have high electrical resistivity and low temperature coefficient.

128. Which one of the following material is used for the swamping resistance of moving coil instruments?

(A) Carbon
(B) Manganin
(C) Silver
(D) Brass

Key: (B)

Exp:



ammeter

129. In a PMMC instrument, the swamping resistor is used to

(A) Increase the damping of the instrument
(B) Reduce the current within safe limits
(C) Compensate for temperature variations
(D) Increase the full-scale sensitivity

Key: (C)

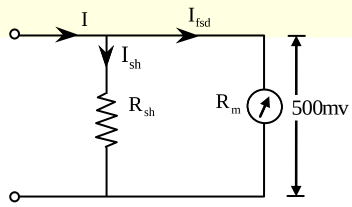
130. A moving coil ammeter has a fixed shunt of $0.02\,\Omega$. With a coil resistance of $R = 1000\Omega$ and a potential difference of 500 mV across it, full scale deflection is obtained. The current through the moving coil to give full scale deflection will be

(A) 25A
(B) 0.5×10^{-2} A
(C) 0.25×10^{-3} A
(D) 0.5×10^{-3} A

Key: (D)

Exp: Given data,

$R_{sh}=0.02\Omega$, $R_m=1000\Omega$, and $V=500mV$.



Current through the moving coil to give full scale deflection =

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$$\frac{500\times10^{-3}}{1000}=0.5\times10^{-3}\text{A.}$$

Current through the shunt

$$=\frac{500\times10^{-3}}{0.02}=25\text{A.}$$

131. A moving iron instrument has full scale current of 100 mA. It is converted into a 250 V voltmeter by using a series resistance made of a material having negligible resistance temperature coefficient. The meter has a resistance of 320 Ω at 20°C. After carrying a steady current of 100mA for a long time, the resistance of the coil increases to 369 Ω due to self heating. When a voltage of 250V is applied continuously, the error due to self-heating will be nearly

(A) –1.1%

(B) –1.9%

(C) –2.5%

(D) –3.3%

Key: (B)

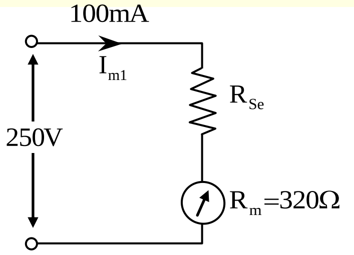
Exp: Total resistance

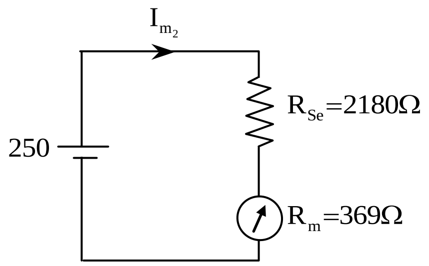
$$\left(R_{se}+R_m\right)=\frac{250}{100\times10^{-3}}=2500\Omega$$

$$\therefore\ R_{se}=2500-R_m=2500-320=2180\Omega.$$

After carrying a steady current of 100mA, meter resistance has changed to 369Ω.

$$\therefore R_{se}+R_m=2180+369=2549\Omega$$





$$\text{Now}\ \Rightarrow I_{m_2}=\frac{250}{369+2180}=98.07\text{mA}$$

$$\%\text{Error}=\frac{I_{m2}-I_{m1}}{I_{m1}}$$

$$=\frac{(98.07-100)}{100}\times100=-1.93\%$$

Hence (B) is correct

132. There will be serious errors if power factor of non-sinusoidal waveform is measured by electrodynamometer power factor meter. This is true for

(A) Single-phase meters alone

(B) 3-phase meters only

(C) Both Single-phase meters and 3-phase meters

(D) 3-Phase meters with balanced loads

Key: (A)

Exp: The electrodynamometer type 3 phase power factor meter, the meter gives indications which are independent of waveform and frequency of supply because the currents in the two moving coils are equally affected by any change of frequency.

However, in single phase power factor meter, the instrument is used at the frequency for which it is designed. Otherwise, it gives serious error as the reactance of the choke coil will change at different frequency.

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133. The ramp type digital voltmeter can measure accurately with

(A) A positive going ramp voltage only

(B) A negative or positive going linear ramp voltage

(C) A negative going ramp voltage only

(D) An asymptotic ramp voltage only

Key: (B)

Exp: The ramp type digital voltmeter can measure accurately with negative & positive going linear ramp voltage.

134. The self-capacitance of a coil is measured by the resonating capacitor. The measurement gives the value of tuning capacitor as $C_1 = 460\text{ pF}$ at a frequency, $f_1 = 2\text{MHz}$. The second measurement at $f_2 = 4\text{ MHz}$ yields a new value of tuning capacitor, $C_2 = 100\text{ pF}$. The distributed capacitance C_d will be

(A) 10 pF

(B) 20 pF

(C) 30 pF

(D) 40 pF

Key: (B)

Exp: Given data,

$C_1 = 460\text{pf},\ f_1 = 2\text{mHz},\ f_2 = 4\text{mHz}$

$C_2 = 100\text{pf},\ n = \frac{f_2}{f_1} = 2.$

$$C_d = \frac{C_1 - n^2 C_2}{n^2 - 1} = \frac{460 - 4\times 100}{4-1} = \frac{60}{3} = 20\text{pf}$$

135. Vertical delay line in CRO

(A) Gives proper time for thermionic emission of electrons

(B) Delays the signal voltage by 200 ns

(C) Allows the horizontal sweep to start prior to vertical deflection

(D) Delays the generation of sweep voltage

Key: (C)

Exp: Vertical delay live in CRO allows the horizontal sweep to start prior to vertical deflection.

136. A 0-150 V voltmeter has a guaranteed accuracy of 1% full scale reading. The voltage measured by this instrument is 83 V. The limiting error will be nearly

(A) 1.2%

(B) 1.8%

(C) 2.4%

(D) 3.2%

Key: (B)

Exp: $$\%LE = \frac{\%GA \times \text{fullscale}}{\text{Reading of instrument}}$$

$$= \frac{\%1 \times 150}{83} = 1.8\%$$

137. The variations in the measured quantity due to sensitivity of transducer to any plane other than the require plane is

(A) Cross sensitivity

(B) Sensitivity

(C) Interference

(D) Distributed sensitivity

Key: (A)

Exp: Sometimes situation may occur where the equipment is very sensitive to the plane perpendicular to the required plane and we have to abandon that equipment due to erroneous result. The variation in the measured quantity due to sensitivity of transducer to any plane other than the required plane is called cross-sensitivity.

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138. A resistance strain gauge with a gauge factor of 2 is fastened to a steel member subjected to a stress of 1050 kg/cm^2. The modulus of elasticity of steel is $2.1\times10^6\ kg/cm^2$. The change in resistance ΔR of the strain gauge element due to the applied stress will be

(A) 0.1%

(B) 0.2%

(C) 0.3%

(D) 0.4%

Key: (A)

Exp: Given data, $G_f = 2$

$$\text{Stress} = 1050\text{kg}/\text{cm}^2,$$

$$y_{steel} = 2.1\times10^6\text{kg/cm}^2, \frac{\Delta R}{R} = ?\ (\text{in }\%)$$

$$G_f = \frac{\Delta R/R}{\Delta\ell/\ell} \Rightarrow \frac{\Delta R}{R}\times100 = 100\times G_f\times\frac{\Delta\ell}{\ell}$$

$$= 100\times2\times\frac{1}{2.1\times10^6}\times1050 = 0.1\%$$

139. In which one of the following classes of computers, is the relationship between architecture and organization very close?

(A) Microcomputers

(B) Mini computers

(C) Mainframe computers

(D) Super computers

Key: (A)

Exp: Computer organization is about what the different functional units of computer are and how they are corrected with each other. Computer architecture is about details how each unit is implemented. Micro computer are simple small computer where everything is implemented on a single board.

140. The decimal equivalent of binary number 1001.101 is

(A) 9.750

(B) 9.625

(C) 10.750

(D) 10.625

Key: (B)

Exp: Given binary number = 1001.101

$$\Rightarrow \left(1\times2^3+0\times2^2+0\times2^1+1\times2^0\right).\left(1\times2^{-1}+0\times2^{-2}+1\times2^{-3}\right)$$

$$\Rightarrow (8+1).\left\{\frac{1}{2}+\frac{1}{8}\right\}$$

$$\Rightarrow 9.\{0.5+0.125\} = (9.625)_{10}$$

141. Convert decimal 41.6875 into equivalent binary:

(A) 100101.1011

(B) 100101.1101

(C) 101001.1011

(D) 101001.1101

Key: (C)

Exp:

2	41	1
2	20	0
2	10	0
2	5	1
2	2	0
	1	

$(41)_{10} = (101001)_2$

$$0.6875\times2 = 1.375 \Rightarrow 1$$
$$0.0.375\times2 = 0.75 \Rightarrow 0$$
$$0.75\times2 = 1.5 \Rightarrow 1$$
$$0.5\times2 = 1 \Rightarrow 1$$

$(0.6875)_{10} = (1011)_2$

Hence $(41.6875)_{10} = (101001.1011)_2$

142. The Central Processing Unit (CPU) consists of

(A) ALU and Control unit only

(B) ALU, Control unit and Registers only

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(C) ALU, Control unit and system bus only

(D) ALU, Control unit, Registers and Internal bus

Key: (D)

Exp: CPU is consists of Arithmetic logic unit, Control unit, General purpose registers, flag registers and Internal bus correcting all units.

143. When enough total memory space exists to satisfy a request, but it is not contiguous, then this problem is known as

(A) Internal Fragmentation

(B) External Fragmentation

(C) Overlays

(D) Partitioning

Key: (B)

Exp: When enough total memory space exists to satisfy a request, but it is not contiguous, then this problem is known as external fragmentation. When requested memory is less than a single page size then this problem is known as internal fragmentation.

144. The total average read or write time T_{total} is

(A) $T_s + \frac{1}{2r} + \frac{b}{N}$

(B) $T_s + \frac{1}{2r} + \frac{b}{rN}$

(C) $\frac{T_s}{rN} + \frac{b}{N}$

(D) $T_s + 2r + \frac{b}{rN}$

where,

$T_s =$ average seek time

$b =$ number of bytes to be transferred

N = number of bytes on a track

$r =$ rotation speed, in revolutions per second

Key: (B)

Exp: Seek Time: Seek time is the time required to move the disk arm to the required track. It turns out that this is a difficult quantity to pin down. The seek time consists of two key components: the initial startup time, and the time taken to traverse the tracks that have to be crossed once the access arm is up to speed. Unfortunately, the traversal time is not a linear function of the number of tracks, but includes a settling time (time after positioning the head over the target track until track identification is confirmed).

Rotational Delay: half of the one rotation time.

Transfer Time: The transfer time to or from the disk depends on the rotation speed of the disk in the following fashion:

$$T = \frac{b}{rN}$$

Where

$T =$ transfer time

$b =$ number of bytes to be transferred

N = number of bytes on a track

r = rotation speed, in revolution per second

Thus the total average access time can be expressed as

$$T_a = T_s + \frac{1}{2r} + \frac{b}{rN}$$

Where T_S is the average seek time. Note that on a zoned drive, the number of bytes per track is variable , complicating the calculation.

145. If a cache has 64-byte cache lines, how long does it take to fetch a cache line if the main memory takes 20 cycles to respond to each

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memory request and returns 2 bytes of data in response to each request?

(A) 980 cycles

(B) 640 cycles

(C) 320 cycles

(D) 160 cycles

Key: (B)

Exp: The main memory takes 20 cycles to respond to each memory request and returns 2 bytes of data.

The number of request to access 64-bytes of the cache is $=\frac{64}{2}=32$

Each request takes 20 cycles hence 32 request will take = $32\times20=640$ cycles

146. Which of the following statements are correct about SRAM?

1. It provides faster access as compared to DRAM.

2. It is cheaper than DRAM.

3. It is more expensive than DRAM.

4. It has higher bit density than DRAM.

(A) 1 and 4 only.

(B) 1 and 3 only.

(C) 1, 3 and 4 only

(D) 2 and 4 only

Key: (B)

147. Features of solid state drives (SSDs) are

1. High-performance in input/output operations per second

2. More power consumption than comparable size HDDs

3. Lower access times and latency rates

4. More susceptible to physical shock and vibration

(A) 2 and 3 only

(B) 2 and 4 only

(C) 1 and 3 only

(D) 1 and 4 only

Key: (C)

Exp: SSD can be thought of as an oversized and more sophisticated version of the humble USB memory stick. Like a memory stick, there are no moving parts to an SSD. Rather, information is stored in microchips. Conversely, a hard disk drive uses a mechanical arm with a read/write head to move around and read information from the right location on a storage platter. That's leads to high performance and lower access time.

148. The decimal value of signed binary number 11101000 expressed in 1's complement is

(A) -223

(B) -184

(C) -104

(D) -23

Key: (D)

Exp: Given

11101000

00010111 ← 1'λ Complement of given binary number

⇓

$(23)_{10}$ → Magnitude.

MSB of given Binary number is 1 hence it is –Ve number $(-23)_{10.}$

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149. The memory management function of virtual memory includes

1. Space allocation

2. Program relocation

3. Program execution

4. Code sharing

(A) 1, 2 and 3 only

(B) 1, 2 and 4 only

(C) 1, 3 and 4 only

(D) 2, 3 and 4 only

Key: (B)

Exp: Memory management unit responsible for memory allocation, relocation of a program if required and if there exists a memory shared between two processes.

150. Which of the following instructions of 8085 are the examples of implied addressing?

1. CMA

2. IN byte

3. RET

(A) 1, 2 and 3

(B) 1 and 2 only

(C) 2 and 3 only

(D) 1 and 3 only

Key: (D)

Exp: Implied Addressing Mode: **Implied Addressing Mode** also known as "**Implicit**" or "Inherent" **addressing mode** is the **addressing mode** in which, no operand(register or memory location or data) is specified in the instruction.

The Complement Accumulator (**CMA**) **instruction** provides a 1's complement of the 8 bits in the A register, i.e the 1's are set to 0's and the 0's are set to 1's. No operand is supplied.

RET **instruction issued** within the called procedure to resume execution flow at the **instruction** following the call. The optional numeric (16- or 32-bit) parameter to **ret** specifies the number of stack bytes or words to be released after the return address is popped from the stack.

IN byte: In this instruction we need to provide address of the Input/output unit from where input is taken hence not an implied address.

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