Practice Paper EE_D

Q. 1- Q. 25 CARRY ONE MARK EACH.

MCQ 1.1 Let $f(x) = e^x$ in $[0,1]$. Then, the value of c of the mean-value theorem is

(A) 0.5 (B) $(e-1)$

(C) $\log(e-1)$ (D) None

SOL 1.1 Option (C) is correct.

$$f'(c) = \frac{f(1)-f(0)}{(1-0)} \Rightarrow e^c = e-1$$

$$\Rightarrow \quad c = \log(e-1)$$

MCQ 1.2 $\int \frac{dx}{\sqrt{x-x^2}}$ is equal to

(A) $\sqrt{x-x^2}+c$ (B) $\sin^{-1}(2x-1)+c$

(C) $\log(2x-1)+c$ (D) $\tan^{-1}(2x-1)+c$

SOL 1.2 Option (B) is correct.

$$\int \frac{dx}{\sqrt{x}\sqrt{1-x}} = I$$

Put $x = \sin^2\theta \Rightarrow dx = 2\sin\theta\cos\theta\, d\theta$

$$I = \int \frac{2\sin\theta\cos\theta}{\sin\theta\sqrt{1-\sin^2\theta}}\,d\theta = \int \frac{2\sin\theta\cos\theta}{\sin\theta\cos\theta}\,d\theta$$

$$I = \int 2\,d\theta = 2\theta + c = 2\sin^{-1}\sqrt{x} + c$$

$$I = \sin^{-1}(2x-1) + c$$

MCQ 1.3 The particular integral for the differential equation

$$\frac{d^3y}{dx^3} - \frac{d^2y}{dx^2} - 6\frac{dy}{dx} = 1 + x^2 \text{ is given by}$$

(A) $\frac{1}{9}x^3 + \frac{1}{4}x^2 = \frac{25}{12}x$ (B) $-\frac{x^3}{18} + \frac{x^2}{36} - \frac{25}{108}x$

(C) $x^3 - \frac{1}{2}x^2 - \frac{25}{9}x$ (D) $\frac{1}{3}x^2 + \frac{1}{12}x^2 - \frac{25}{36}x$

SOL 1.3 Option (B) is correct.

MCQ 1.4 The value of $\frac{1}{2\pi i}\int_c \frac{\cos \pi z}{z^2 - 1}dz$ around a rectangle with vertices at $2 \pm i, -2 \pm i$ is

(A) 6 (B) $i2e$

(C) 8 (D) 0

SOL 1.4 Option (D) is correct.

Let,
$$I = \frac{1}{2\pi i}\int_c \frac{1}{z^2 - 1}\cos \pi z dz$$
$$= \frac{1}{2.2\pi i}\int_c \left(\frac{1}{z-1} - \frac{1}{z+1}\right)\cos \pi z dz$$

Or
$$I = \frac{1}{4\pi i}\int_c \left(\frac{\cos \pi z}{z-1} - \frac{\cos \pi z}{z+1}\right)dz = 0$$

MCQ 1.5 Resolution of 4-bit analog to digital converter in percent is

(A) 6.25% (B) 6.67%

(C) 12.5% (D) 25%

SOL 1.5 Option (B) is correct.

% Resolution $= \frac{1}{2^n - 1} \times 100 = \frac{1}{2^4 - 1} \times 100 = 6.67\%$

MCQ 1.6 A logical function of four variable is given as

$f(A, B, C, D) = (\overline{A} + BC)(B + CD)$

The function as a sum of product is

(A) $\overline{A} + BC + A\overline{C}D + BCD$

(B) $\overline{A} + BC + \overline{A}CD + BCD$

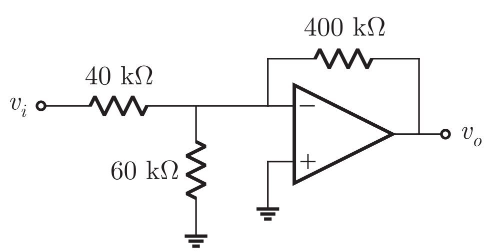
(C) $\overline{A}B + BC + \overline{A}CD + BCD$

(D) $AB + A\overline{B} + A\overline{C}D + BCD$

SOL 1.6 Option (C) is correct.

$$f = (\overline{A} + BC)B + (\overline{A} + BC)CD$$
$$= \overline{A}B + BC + \overline{A}CD + BCD$$

MCQ 1.7 For the circuit shown below the value of $A_v = \frac{v_o}{v_i}$ is



(A) -10 (B) 10

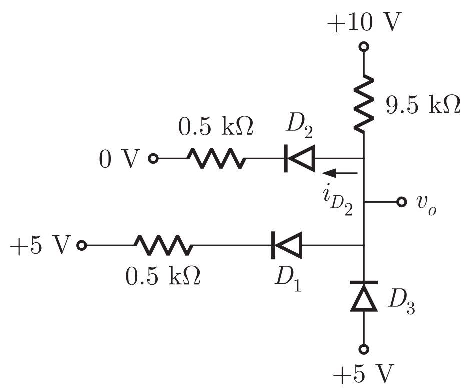
(C) 13.46 (D) -13.46

SOL 1.7 Option (A) is correct.

The noninverting terminal is at ground level. Thus inverting terminal is also at virtual ground. There will not be any current in 60 kΩ.

$$A_v = -\frac{400}{40} = -10$$

MCQ 1.8 The diodes in the circuit shown below has parameters $V_\gamma = 0.6$ V and $r_f = 0$. The current i_{D_2} is



(A) 8.4 mA (B) 10 mA

(C) 7.6 mA (D) 0 mA

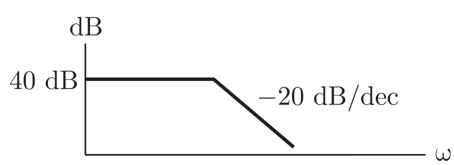
SOL 1.8 Option (C) is correct.

D_2 and D_3 are ON. If D_3 is ON, then D_1 is OFF.

$$v_o = 5 - 0.6 = 4.4 \text{ V},$$

$$i_{D_2} = \frac{4.4 - 0.6}{0.5\text{k}} = 7.6 \text{ mA}$$

MCQ 1.9 The Bode plot for a transfer function is shown in fig below. The steady state error corresponding to a unit step input is



(A) $\frac{1}{100}$ (B) $\frac{1}{101}$

(C) $\frac{1}{41}$ (D) $\frac{1}{40}$

SOL 1.9 Option (B) is correct.

MCQ 1.10 The open-loop transfer function with *ufb* are given below for different systems. The unstable system is

(A) $\frac{2}{s+2}$ (B) $\frac{2}{s^2(s+2)}$

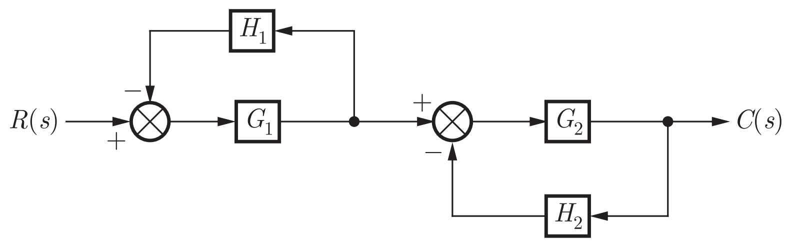
(C) $\frac{2}{s(s-2)}$

(D) $\frac{2(s+1)}{s(s+2)}$

SOL 1.10 Option (B) is correct.

In characteristic equation $s^3 + 2s^2 + K$, the term s is missing.

MCQ 1.11 A system is shown below. The transfer function for this system is



(A) $\frac{G_1 G_2}{1 + G_1 G_1 H_2 + G_2 H_1}$

(B) $\frac{G_1 G_2}{1 + G_1 G_2 + H_1 H_2}$

(C) $\frac{G_1 G_2}{1 - G_1 H_1 - G_2 G_2 + G_1 G_2 H_1 H_2}$

(D) $\frac{G_1 G_2}{1 + G_1 H_1 + G_2 H_2 + G_1 G_2 H_1 H_2}$

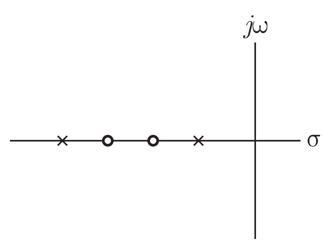
SOL 1.11 Option (D) is correct.

Apply the feedback formula to both loop and then multiply.

$$T(s) = \left(\frac{G_1}{1 + G_1 H_1}\right)\left(\frac{G_2}{1 + G_2 H_2}\right)$$

$$= \frac{G_1 G_2}{1 + G_1 H_1 + G_2 H_2 + G_1 G_2 H_1 H_2}$$

MCQ 1.12 The pole-zero plot shown below is that of a



(A) PID controller

(B) PD controller

(C) Integrator

(D) Lag-lead compensating network

SOL 1.12 Option (D) is correct.

MCQ 1.13 A magnetic circuit with a cross-sectional area of 20 cm^2 is to be operated at 50 Hz from a 120 V rms supply. The number of turns required to achieve a peak magnetic flux density of 1.8 T in the core is

(A) 942

(B) 106

(C) 150

(D) 666

SOL 1.13 Option (C) is correct.

Number of turns

$$N = \frac{\sqrt{2}\,V_{rms}}{\omega A B_{\text{peak}}}$$

$$= \frac{\sqrt{2} \times 120}{2\pi \times 50 \times 20 \times 10^{-4} \times 1.8}$$

$$= 150$$

MCQ 1.14 What is the increase in the torque expressed as percentage of initial torque, if the current drawn by a dc series motor is increased from 10 A to 12 A (Neglect saturation) ?

(A) 21% (B) 25%

(C) 41% (D) 44%

SOL 1.14 Option (D) is correct.

For a dc series motor $T \propto I_a^2$

$$\frac{T_1}{T_2} = \left(\frac{I_{a1}}{I_{a2}}\right)^2 = \left(\frac{10}{12}\right)^2$$

or $T_2 = 1.44\,T_1$

the percentage increment in torque is

$$\Delta T = \frac{T_2 - T_1}{T_1} \times 100 = 44\%$$

MCQ 1.15 Which one of the following is not a necessary condition to be satisfied for synchronizing an incoming alternator to an already operating alternator ?

(A) Same voltage magnitude

(B) Same frequency

(C) Same prime mover speed

(D) Same phase sequence

SOL 1.15 Option (C) is correct.

The following requirements have to be satisfied prior to connecting an alternator to an already operating alternator

- The line voltage of the (incoming) alternator must be equal to the constant voltage of the already operating alternator.
- The frequency of the incoming alternator must be exactly equal to that of the already operating alternator
- The phase sequence of the incoming alternator must be identical to the phase sequence of the already operating alternator
- The prime mover speed of the alternators should be different for operation.

MCQ 1.16 An induction motor when started on load does not accelerate up to full speed but runs at 1/7 th of the rated speed. The motor is said to be

(A) locking (B) plugging

(C) crawling (D) cogging

SOL 1.16 Option (C) is correct.

A cage motor shows peculiar behavior at starting because the motor has a certain relationship between the number of poles and the stator and rotor slots. For some ratio of rotor-to-stator slots, the machine may run stably at a low speed(1/7 of the rated speed). This phenomena is called crawling.

MCQ 1.17 In a stepper motor, the detent torque means

(A) minimum of the static torque with the phase winding excited

(B) maximum of the static torque with the phase winding excited

(C) minimum of the static torque with the phase winding unexcited

(D) maximum of the static torque with the phase winding unexcited

SOL 1.17 Option (D) is correct.

Detent torque/Restraining toque:

The residual magnetism in the permanent magnetic material produced.

The detent torque is defined as the maximum load torque that can be applied to the shaft of an unexcited motor without causing continuous rotation. In case the motor is unexcited.

MCQ 1.18 Consider a discrete-time system S whose response to a complex exponential input $e^{j\pi n/2}$ is specified as

$$S: e^{j\pi/2} \Rightarrow e^{j\pi 3n/2}$$

The system is

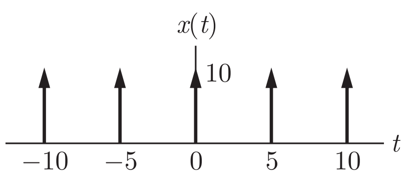
(A) definitely LTI (B) definitely not LTI

(C) may be LTI (D) information is not sufficient

SOL 1.18 Option (B) is correct.

The input $e^{j\pi n/2}$ must produce the output is the form $Ae^{j\pi m/2}$. The output in this case is $e^{j3\pi n/2}$. This violates the Eigen function property of LTI system. Therefore, S is definitely not LTI system.

MCQ 1.19 The Fourier series coefficient for the periodic signal shown below is



(A) 1 (B) $\cos\left(\frac{\pi}{2}k\right)$

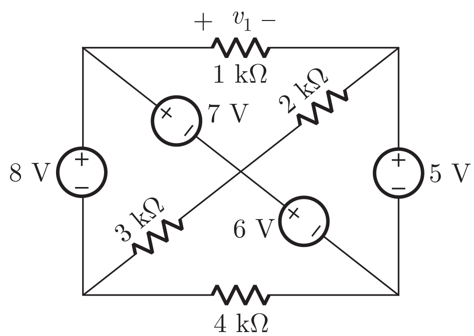
(C) $\sin\left(\frac{\pi}{2}k\right)$ (D) 2

SOL 1.19 Option (D) is correct.

$$X[k] = \frac{1}{T}\int_{-T/2}^{T/2} A\delta(t)\, e^{-jk\omega}\, dt = \frac{A}{T},$$

$A = 10,\ T = 5,\ X[k] = 2$

MCQ 1.20 In the circuit of figure the voltage v_1 is equal to

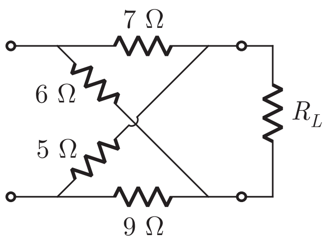


(A) -11 V (B) 5 V
(C) 8 V (D) 18 V

SOL 1.20 Option (C) is correct.
If we go from +side of 1 kΩ through 7 V, 6 V and 5 V, we get

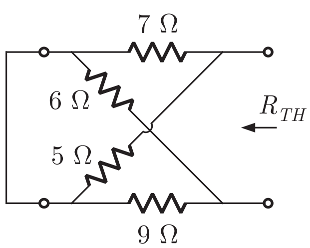
$$v_1 = 7 + 6 - 5 = 8 \text{ V}$$

MCQ 1.21 In the following lattice network the value of R_L for the maximum power transfer to it is



(A) 6.67 Ω (B) 9 Ω
(C) 6.52 Ω (D) 8 Ω

SOL 1.21 Option (C) is correct.
The circuit is as shown below

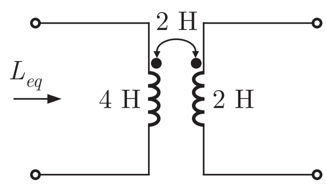


$$R_{TH} = 7 \| 5 + 6 \| 9 = 6.52\,\Omega$$

For maximum power transfer

$$R_L = R_{TH} = 6.52\,\Omega$$

MCQ 1.22 For the circuit shown below the equivalent inductance L_{eq} is



(A) 0.2 H (B) 1 H

(C) 0.4 H (D) 2 H

SOL 1.22 Option (D) is correct.

$$L_{eq} = L_1 - \frac{M^2}{L_2}$$

$$= 4 - \frac{4}{2} = 2 \text{ H}$$

MCQ 1.23 Three loads each of resistance $40\,\Omega$ are connected in a star-configuration with a $240\sqrt{3}$ V three-phase supply. The value of phase voltage and phase current are respectively-

(A) $240\sqrt{3}$ V, $6\sqrt{3}$ A (B) 240 V, 6 A

(C) 80 V, $6\sqrt{3}$ A (D) $240\sqrt{3}$ V, 6 A

SOL 1.23 Option (B) is correct.

For a star connection

$$V_p = \frac{V_L}{\sqrt{3}} \qquad V_p \rightarrow \text{Phase voltage}$$
$$V_L \rightarrow \text{line voltage}$$

So $$V_p = \frac{240\sqrt{3}}{\sqrt{3}} = 240 \text{ V}$$

$$I_p = \frac{V_p}{R_p} = \frac{240}{40} = 6 \text{ A}$$

MCQ 1.24 Consider the following statements in respect of load flow studies in power systems :

1. Bus admittance matrix is a sparse matrix
2. Gauss-Seidel method is preferred over Newton-Raphson method for load flow studies
3. One of the buses is taken as slack bus in load flow studies

Which of the statements given above are correct ?

(A) 1, 2 and 3 (B) 1 and 2

(C) 1 and 3 (D) 2 and 3

SOL 1.24 Option (C) is correct.

1. BUS admittance matrix is a sparse matrix.
2. GS method is easier but it is less accurate and has a slow convergence rate compare to NR method .So, GS method is not preferred over NR method.
3. One of the buses is taken as slack bus in power flow studies.

MCQ 1.25 An unknown voltage is applied to the horizontal deflection plate of a CRO, which shifts the spot by 5 mm towards the right. If the deflection sensitivity is 0.05 mm/V, then the applied unknown voltage is

(A) 25 V (B) 10 V

(C) 100 V (D) 50 V

SOL 1.25 Option (C) is correct.

Deflection sensitivity $= 0.05\,\text{mm/V}$

Spot deflection $= 5\,\text{mm}$

Applied voltage $= \frac{5}{0.05} = 100\text{ V}$

Q. 26- Q. 55 CARRY TWO MARK EACH.

MCQ 1.26 A single-phase fully controlled thyristor bridge ac-dc converter is operating at a firing angle of 25° and an overlap angle of 10° with constant dc output current of 20 A. The fundamental power factor (displacement factor) at input ac mains is

(A) 0.78 (B) 0.827

(C) 0.866 (D) 0.9

SOL 1.26 Option (A) is correct.

Firing angle $\alpha = 25^\circ$

Overlap angle $\mu = 10^\circ$

so, $I_0 = \frac{V_m}{\omega Ls}[\cos\alpha - \cos(\alpha+\mu)]$

$\therefore \quad 20 = \frac{230\sqrt{2}}{2\pi\times 50Ls}[\cos 25^\circ - \cos(25^\circ + 10^\circ)]$

$\therefore \quad Ls = 0.0045\text{ H}$

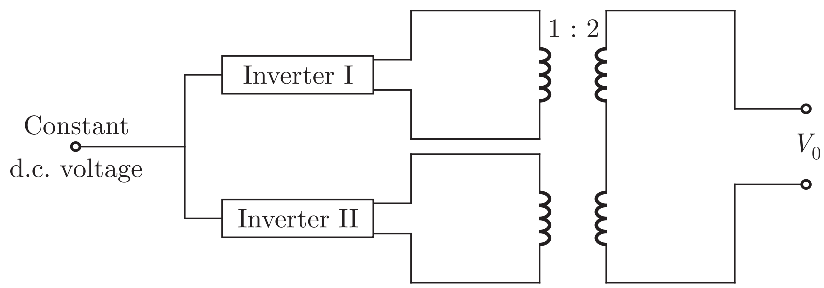
$$V_0 = \frac{2V_m\cos\alpha}{\pi} - \frac{\omega LsI_0}{\pi}$$

$$= \frac{2\times 230\sqrt{2}\cos 25^\circ}{3.14} - \frac{2\times 3.14\times 50\times 4.5\times 10^{-3}\times 20}{3.14}$$

$$= 187.73 - 9 = 178.74^\circ$$

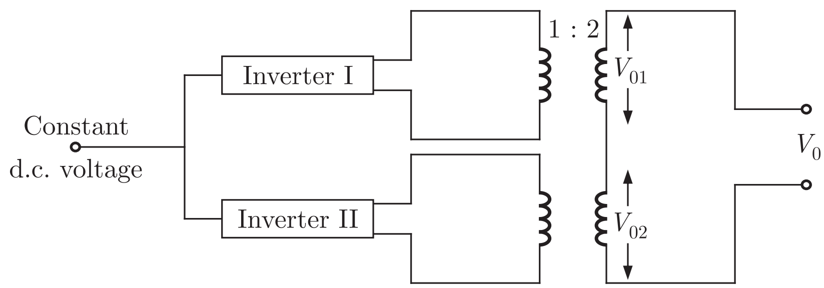
Displacement factor $= \frac{V_0I_0}{V_sI_s} = \frac{178.25\times 20}{230\times 20} = 0.78$

MCQ 1.27 The following figure shows a circuit for harmonic reduction of an inverter system. Each inverter has output voltage of 400 V and each transformer has primary to secondary turns ratio of 1 : 2 . If the firing angles for the two inverter differ by 30° , the output voltage will be



(A) 1.54 kV
(B) 386.37 V
(C) 772.74 V
(D) 1.38 kV

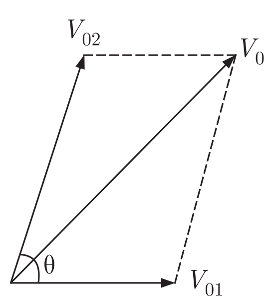
SOL 1.27 Option (A) is correct.



Output of the inverters

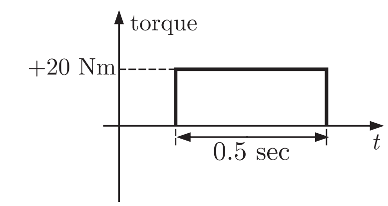
$$\therefore \qquad V_{01} = 2 \times 400 \text{ and } V_{02} = 2 \times 400$$

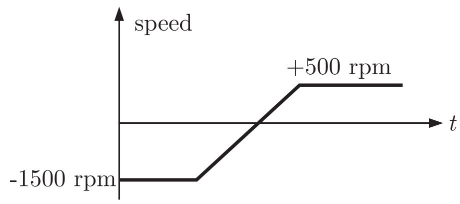
From the phaser diagram the output voltage is given as



$$V_0 = [V_{01}^2 + V_{01}^2 + 2V_{01}V_{02}\cos\theta]^{\frac{1}{2}}$$
$$= [(800)^2 + ((800)^2 + 2 \times 800 \times 800\cos 30^\circ)]^{\frac{1}{2}}$$
$$= 1.54 \text{ kV}$$

MCQ 1.28 A variable speed drive rated for 1500 rpm, 40 Nm is reversing under no load. Figure shows the reversing torque and the speed during the transient. The moment of inertia of the drive is

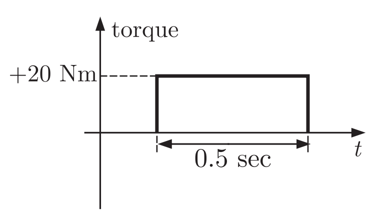


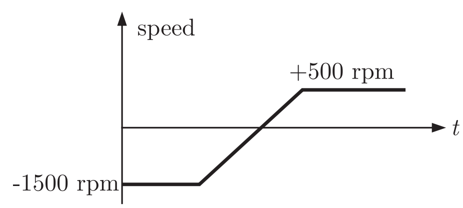


(A) 0.048 kg-m^2 (B) 0.064 km-m^2

(C) 0.096 kg-m^2 (D) 0.128 kg-m^2

SOL 1.28 Option (C) is correct.





so

$$\alpha = \left[\frac{500 - (-1500)}{0.5}\right] \times \frac{2\pi}{60} = 418.67 \text{ rad/sec}^2$$

and $T = 40$ Nm

$$T = I\alpha$$

$$I = \frac{T}{\alpha} \times \frac{40}{418.67} = 0.096 \text{ kgm}^2$$

MCQ 1.29 A single phase short-transmission line is feeding a load of 12 kW at a 0.8 lagging power factor. The transmission line resistance and reactance are $5\,\Omega$ and $10\,\Omega$ respectively. If the terminal voltage across the load is 440 V, then what is the transmission efficiency ?

(A) 48.45% (B) 76.34%

(C) 67.36% (D) 32.64%

SOL 1.29 Option (C) is correct.

Impedance $Z = 5 + j10 = 11.2\angle 63.4^\circ\ \Omega$

Line current $I = \frac{12000}{440 \times 0.8}\angle -36.86^\circ$

$= 34.1\angle -36.86^\circ$ A

Transmission line loss $P_L = I^2 R = (34.1)^2 \times 5 = 5814.05$ W

Power at the sending end

$$P_S = 12000 + 5814.05 = 17814.05 \text{ W}$$

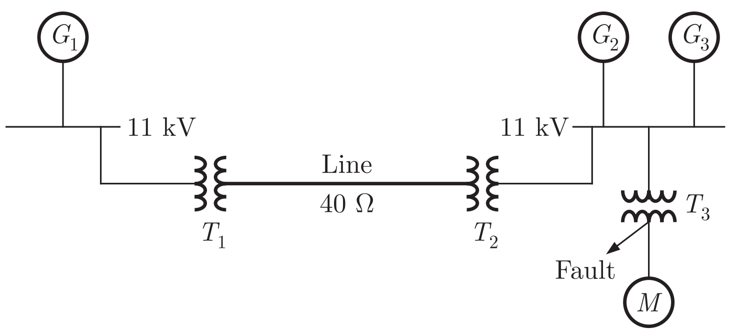
Transmission efficiency

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

$$= \frac{12000}{17814.05} \times 100 = 67.36\%$$

MCQ 1.30 Two generating stations are connected together through transformers and a transmission line as shown in figure. The component specification are given as following

11 kV, 40 MVA, 15%
11 kV, 20 MVA, 10%
11 kV, 20 MVA, 10%
40 MVA, 11/66 kV, 15%
40 MVA, 66/11 kV, 15%
5 MVA, 11/6.6 kV, 8%



If a three phase fault occurs as shown in figure, the fault current is

(A) 2.09 kA (B) 1.37 kA

(C) 1.20 kA (D) 2.87 kA

SOL 1.30 Option (D) is correct.

Let Base MVA is 40 MVA and Base Voltage is 11 kV, reactances on this base will be

Generator G_1

$$X_{G_1} = j0.15 \text{ pu}$$

Generator G_2

$$X_{G_2} = j0.10 \times \frac{40}{20} = j0.20 \text{ pu}$$

Generator G_3

$$X_{G_3} = j0.10 \times \frac{40}{20} = j0.20 \text{ pu}$$

Transformer T_1

$$X_{T_1} = j0.15 \text{ pu}$$

Transformer T_2

$$X_{T_2} = j0.15 \text{ pu}$$

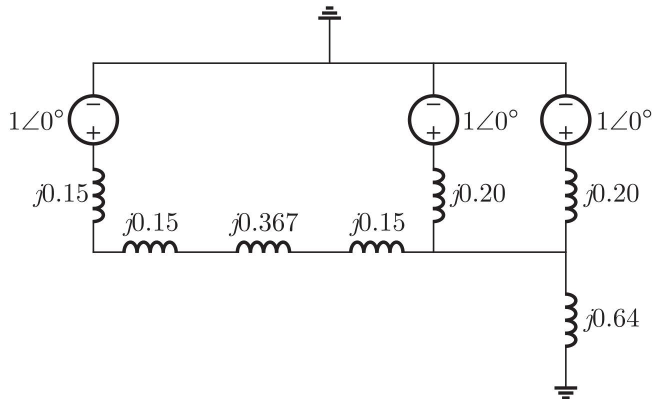
Transformer T_3

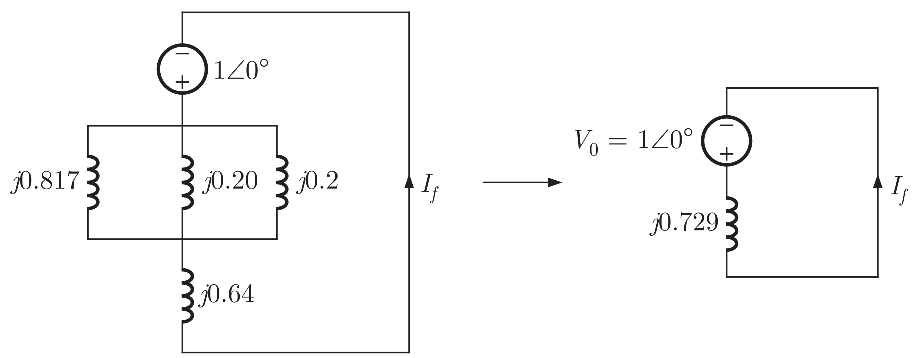
$$X_{T_3} = j0.08 \times \frac{40}{5} = j0.64 \text{ pu}$$

Line

$$X_{Line} = j40 \times \frac{40}{(66)^2} = j0.367 \text{ pu}$$

Equivalent circuit diagram is shown below





Fault current

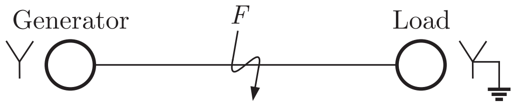
$$I_f = \frac{1\angle 0°}{j0.729} = -j1.37 \text{ pu}$$

Base current $$I_B = \frac{40 \times 1000}{\sqrt{3} \times 11} = 2099.45 \text{ Amp}$$

Fault current in amperes

$$|I_f| = 1.37 \times 2099.45$$
$$= 2.876 \text{ kA}$$

MCQ 1.31 A 3-phase star-connected generator supplies a star-connected inductive load through a transmission line as shown in figure. The load reactance is $j0.5$ pu per phase and the line reactance is $j0.1$ pu per phase. The positive, negative and zero-sequence reactances of the generator are $j0.5$, $j0.5$ and $j0.05$ pu respectively.



A single line-to-ground fault occurs at the mid point of the line. Prior to fault the network is balanced and the voltage at the fault location is $1\angle 0^\circ$ pu. The value of current through the fault path is

(A) $-j2.5$ pu

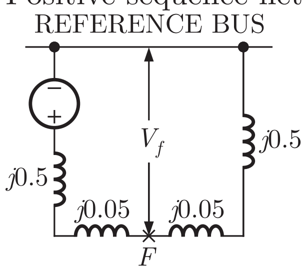
(B) $-j1.90$ pu

(C) $-j3.24$ pu

(D) $-j4.0$ pu

SOL 1.31 Option (A) is correct.

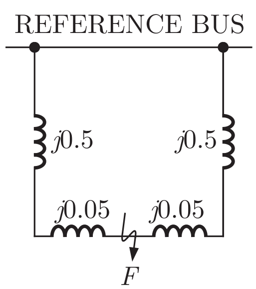
Positive sequence network



Equivalent positive-sequence impedance,

$$Z_{1eq} = j[(0.5+0.05)\,||\,(0.5+0.05)]$$
$$= j0.275 \text{ pu}$$

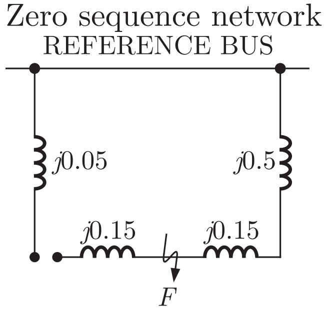
Negative sequence network



Equivalent negative-sequence impedance

$$Z_{2eq} = Z_1 = j0.275 \text{ pu}$$

Zero sequence network

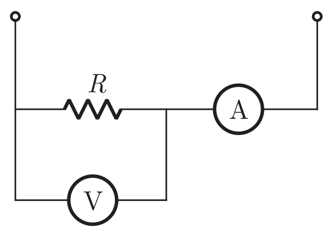


Equivalent zero-sequence impedance,

$$Z_{0eq} = j3 \times 0.05 + j0.5 = j0.65$$

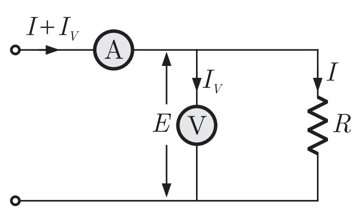
Fault current
$$I_f = \frac{3V_f}{Z_{1eq} + Z_{2eq} + Z_{0eq}}$$
$$= \frac{3 \times (1 + j0)}{j(0.275 + 0.275 + 0.65)}$$
$$= -j2.5 \text{ pu}$$

MCQ 1.32 The set-up in the figure is used to measure resistance R .The ammeter and voltmeter resistances are 0.01Ω and $2000\ \Omega$, respectively. Their readings are 2 A and 180 V, respectively, giving a measured resistances of $90\ \Omega$ The percentage error in the measurement is



(A) 2.25%
(B) 2.35%
(C) 4.5%
(D) 4.71%

SOL 1.32 Option (D) is correct.
The configuration is shown below



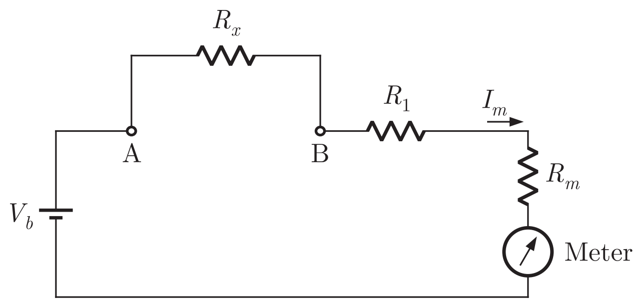
Current in voltmeter is given by
$$I_V = \frac{E}{2000} = \frac{180}{2000} = .09\ \text{A}$$

$$I + I_V = 2 \text{ amp}$$
So
$$I = 2 - .09 = 1.91\ \text{V}$$
$$R = \frac{E}{I} = \frac{180}{1.91} = 94.24\ \Omega$$

Ideally
$$R_0 = \frac{180}{2} = 90\ \Omega$$

$$\%\ \text{error} = \frac{R - R_0}{R_0} \times 100 = \frac{94.24 - 90 \times 100}{90} = 4.71\%$$

MCQ 1.33 The series ohmmeter shown in the figure uses a 100 μA meter and a resistance R_1. It is given that $(R_1 + R_m) = 15\ \text{k}\Omega$, then which of the following statement is true ?



(A) At 25% of full-scale deflection, the measured value of resistance R_x is 10 kΩ

(B) At 50% of full-scale deflection, the measured value of resistance R_x is 15 kΩ

(C) At 75% of full-scale deflection, the measured value of resistance R_x is 45 kΩ

(D) none of above

SOL 1.33 Option (B) is correct.

The meter current indicated by the instrument in the figure

$$I_m = \frac{E_b}{R_x + R_1 + R_m}$$

To obtain full-scale deflection current put $R_x = 0$ in above equation

$$I_{fsd} = \frac{1.5\text{ V}}{0 + 15\text{ k}\Omega} = 100\,\mu\text{A}$$

At 50% of full scale deflection

$$I_m = \frac{100\,\mu\text{A}}{2} = 50\,\mu\text{A}$$

$$R_x + R_1 + R_m = \frac{E_b}{I_m}$$

$$R_x = \frac{E_b}{I_m} - (R_1 + R_m) = \frac{1.5\text{ V}}{50\,\mu\text{A}} - 15\text{ k}\Omega$$

$$= 15\text{ k}\Omega$$

At 25% of full-scale deflection

$$I_m = \frac{100\,\mu\text{A}}{4} = 25\,\mu\text{A}$$

$$R_x = \frac{1.5\text{ V}}{25\,\mu\text{A}} - 15\text{ k}\Omega = 45\text{ k}\Omega$$

At 75% of full scale-deflection

$$I_m = 0.75 \times 100\,\mu\text{A} = 75\,\mu\text{A}$$

$$R_x = \frac{1.5\text{ V}}{75\,\mu\text{A}} - 15\text{ k}\Omega = 15\text{ k}\Omega$$

MCQ 1.34 A 4 kHz sinusoidal signal is being observed on the screen of a CRO. For a sweep frequency of 8 kHz and 2 kHz, the number of cycles of the input signal appeared on the screen will be respectively

(A) 1, 4 (B) 0.5, 1

(C) 4, 1 (D) 0.5, 2

SOL 1.34 Option (D) is correct.

Duration of one cycle of input

$$T = \frac{1}{4} = 0.25\,\text{m sec}$$

When the sweep frequency is 8 kHz, duration of one cycle of sweep

$$T_s = \frac{1}{8} = 0.125\,\text{msec}$$

no of cycles appeared on the screen $= \frac{0.125}{0.25} = 0.5$

When the sweep frequency is 8 kHz, duration of one cycle of sweep

$$T_{s2} = \frac{1}{2} = 0.50\,\text{msec}$$

no of cycles appeared on the screen $= \frac{0.50}{0.25} = 2$

MCQ 1.35 A 50 Hz, bar primary CT has a secondary with 300 turns. The resistance and reactance of secondary circuits are $1.3\,\Omega$ and $0.8\,\Omega$ respectively and it supplies a current of 5 A. The core requires an equivalent of mmf of 90 AT for magnetization and 45 AT for core losses. The actual ratio will be

(A) 317.1 (B) 307.6

(C) 320 (D) 309.4

SOL 1.35 Option (A) is correct.

Secondary circuit phase angle

$$\delta = \tan^{-1}\left(\frac{0.8}{1.3}\right) = 31.6^\circ$$

Turn ratio $K_t = \frac{N_s}{N_p} = \frac{300}{1} = 300$

Magnetizing current

$$I_m = \frac{\text{Magnetising } mmf}{N_p} \qquad \therefore N_p = 1$$

$$= \frac{90}{1} = 90\text{ A}$$

Loss component

$$I_w = \frac{mmf \text{ equivalent to iron loss}}{N_p} = \frac{45}{1} = 45\text{ A}$$

Actual ratio

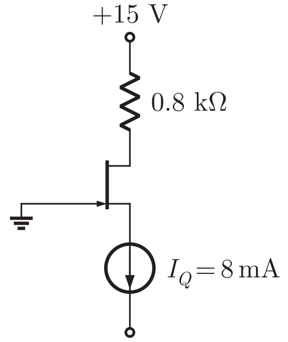
$$K_{act} = K_t + \frac{I_m \sin\delta + I_w \cos\delta}{I_s}$$

Put, $\cos\delta = \cos 31.6^\circ = 0.8517$ and $\sin\delta = \sin 31.6^\circ = 0.524$

$$K_{act} = 300 + \frac{90 \times 0.524 + 45 \times 0.8517}{5} = 317.1$$

MCQ 1.36 For the circuit shown below the transistor parameters are $V_p = -3.5\text{ V}$, $I_{DSS} = 18\text{ mA}$

, and $\lambda = 0$. The value of V_{DS} is



(A) 7.43 V (B) 8.6 V

(C) −1.17 V (D) 1.17 V

SOL 1.36 Option (A) is correct.

Assume the transistor is biased in the saturation region

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

$$8\text{m} = 18\text{m}\left(1 - \frac{V_{GS}}{-3.5}\right)^2 \Rightarrow V_{GS} = -1.17 \text{ V}$$

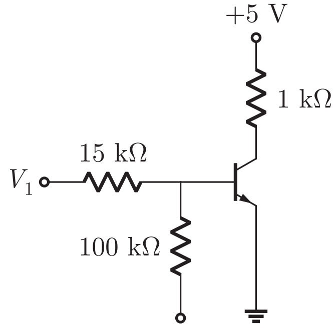
$$V_D = 15 - (8\text{m})(0.8\text{k}) = 8.6 \text{ V}$$

$$V_{DS} = 8.6 - 1.17 = 7.43 \text{ V}$$

$$V_{GS} - V_P = -1.17 - (-3.5) = 2.33 \text{ V}$$

$V_{DS} > V_{GS} - V_p$, Assumption is correct.

MCQ 1.37 For the transistor shown below $\beta = 25$. The range of V_1 such that $1.0 \le V_{CE} \le 4.5$ is



(A) $1.86 \le V_1 \le 3.96$ V (B) $2.81 \le V_1 \le 4.46$ V

(C) $1.43 \le V_1 \le 79$ V (D) $2.18 \le V_1 \le 3.69$ V

SOL 1.37 Option (A) is correct.

For $V_{CE} = 4.5$ V, $I_C = \frac{5 - 4.5}{1\text{k}} = 0.5$ mA

$$I_B = \frac{0.5}{25} = 0.02 \text{ mA}$$

$$R_1 = 15\,\text{k}\Omega,\ R_2 = 100\,\text{k}\Omega$$

$$I_{R2} = \frac{0.7-(-5)}{100\text{k}} = 0.057 \text{ mA}$$

$$I_{R1} = I_{R1} + I_B = 0.057 + 0.02 = 0.077 \text{ mA}$$

$$V_1 = I_{R1}R_1 + V_{BE} = (0.077)15 + 0.7 = 1.855 \text{ V}$$

For $V_{CE} = 1.0$ V

$$I_C = \frac{5-1}{1\text{k}} = 4 \text{ mA},$$

$$I_B = \frac{4}{25} = 0.16 \text{ mA}$$

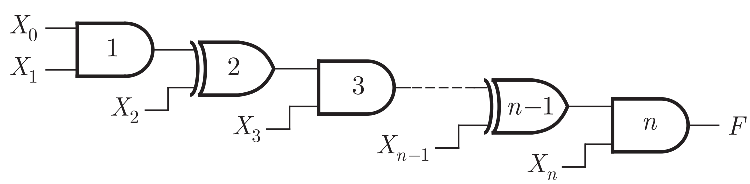
$$I_{R2} = 0.057 \text{ mA}$$

$$I_{R1} = 0.057 + 0.16 = 0.217 \text{ mA}$$

$$V_1 = (0.217)(15) + 0.7 = 3.96 \text{ V}$$

So $1.86 \le V_1 \le 3.96$ V

MCQ 1.38 In the network shown below f can be written as



(A) $X_0X_1X_3X_5 + X_2X_4X_5...X_{n-1} + ...X_{n-1}X_n$

(B) $X_0X_1X_3X_5 + X_2X_3X_4...X_n + ...X_{n-1}X_n$

(C) $X_0X_1X_3X_5...X_n + X_2X_3X_5 + ...X_n + ... + X_{n-1}X_n$

(D) $X_0X_1X_3X_5...X_{n-1} + X_2X_3X_5...X_n + ... + X_{n-1}X_{n-2} + X_n$

SOL 1.38 Option (C) is correct.

Output of gate 1 is X_oX_1

Output of gate 2 is $X_0X_1 + X_2$

Output of gate 3 is

$$(X_0X_1 + X_2)X_3 = X_0X_1X_3 + X_2X_3$$

Output of gate 4 would be $X_0X_1X_3 + X_2X_3 + X_4$

Output of gate 5 would be

$$X_0X_1X_3X_5 + X_2X_3X_5 + X_4X_5$$

So output of gate n would be

$X_oX_1X_3X_5...X_n + X_2X_3X_5...X_n + X_4X_5X_7...X_n + X_{n-1}X_n$

MCQ 1.39 The sum and product of the mean and variance of a binomial distribution are 24 and 128 respectively. Then, the distribution is

(A) $\left(\frac{1}{7}+\frac{1}{8}\right)^{12}$

(B) $\left(\frac{1}{4}+\frac{3}{4}\right)^{16}$

(C) $\left(\frac{1}{6}+\frac{5}{6}\right)^{24}$ (D) $\left(\frac{1}{2}+\frac{1}{2}\right)^{32}$

SOL 1.39 Option (D) is correct.

$m+\sigma^2 = 24$ and $m\sigma^2 = 128$

On solving we get : $m = 16$ or 8

$m = 16 \Rightarrow \sigma^2 = 8$ $m = 8 \Rightarrow \sigma^2 = 56$

Case I : $np = 16$ and $npq = 8$

$\Rightarrow p = \frac{1}{2}$ and $q = \frac{1}{2}$ and $n = 32$

Case II : $np = 8$ and $npq = 56$

$\Rightarrow q = 7$, which is not possible.

The distribution is $(q+p)^n = \left(\frac{1}{2}+\frac{1}{2}\right)^{32}$

MCQ 1.40 For $\frac{dy}{dx} = xy$ given that $y = 1$ at $x = 0$. Using Euler method taking the step size 0.1, the y at $x = 0.4$ is

(A) 1.0611 (B) 2.4680

(C) 1.6321 (D) 2.4189

SOL 1.40 Option (A) is correct.

x : 0 0.1 0.2 0.3 0.4

Euler's method gives

$$y_{n+1} = y_n + h(x_n, y_n) \quad \text{...(i)}$$

$n = 0$ in (1) gives

$$y_1 = y_0 + hf(x_0, y_0)$$

Here $x_0 = 0$, $y_0 = 1$, $h = 0.1$

$$y_1 = 1 + 0.1f(0,1) = 1 + 0 = 1$$

$n = 0$ in (1) gives $y_2 = y_1 + hf(x_1, y_1)$

$$= 1 + 0.1f(0.1,1) = 1 + 0.1(0.1) = 1 + 0.01$$

Thus $y_2 = y_{(0.2)} = 1.01$

$n = 2$ in (1) gives

$$y_3 = y_2 + hf(x_2, y_2) = 1.01 + 0.1f(0.2, 1.01)$$

$$y_3 = y_{(0.3)} = 1.01 + 0.0202 = 1.0302$$

$n = 3$ in (1) gives

$$y_3 = y_2 + hf(x_2, y_2) = 1.01 + 0.1f(0.2, 1.01)$$

$$y_3 = y_{(0.3)} = 1.01 + 0.0202 = 1.0302$$

$n = 3$ in (1) gives

$$y_4 = y_3 + hf(x_3, y_3) = 1.0302 + 0.1f(0.3, 1.0302)$$

$$= 1.0302 + 0.03090$$

$$y_4 = y_{(0.4)} = 1.0611$$

Hence $y_{(0.4)} = 1.0611$

MCQ 1.41 The system of equations $x-4y+7z=14$, $3x+8y-2z=13$, $7x-8y+26z=5$ has

(A) a unique solution

(B) no solution

(C) an infinite number of solution

(D) none of these

SOL 1.41 Option (B) is correct.

Here
$$[\mathbf{A}:\mathbf{B}] = \begin{bmatrix} 1 & -4 & 7 & : & 14 \\ 3 & 8 & -2 & : & 13 \\ 7 & -8 & 26 & : & 5 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & -4 & 7 & : & 14 \\ 0 & 20 & -23 & : & -29 \\ 7 & 20 & -23 & : & -93 \end{bmatrix} \qquad \begin{pmatrix} R_2 - R_1 \Rightarrow R_2 \\ R_3 - 3R_1 \Rightarrow R_3 \end{pmatrix}$$

$$= \begin{bmatrix} 1 & -4 & 7 & : & 14 \\ 0 & 20 & -23 & : & -29 \\ 7 & 0 & 0 & : & -64 \end{bmatrix} \qquad (R_3 - R_2 \Rightarrow R_3)$$

$$\rho(\mathbf{A}:\mathbf{B}) = 3 \ \& \ \rho(\mathbf{A}) = 2,$$
$$\rho(\mathbf{A}) \neq \rho(\mathbf{A}:\mathbf{B})$$

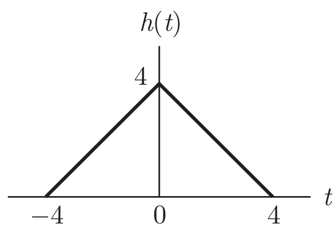
Thus system is inconsistent i.e. has no solution.

MCQ 1.42 Two systems have impulse responses as

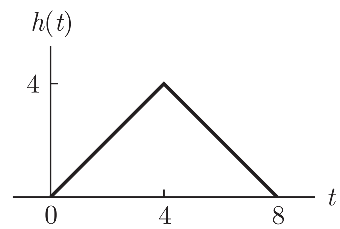
$$h_1(t) = u(t) - u(t-4) \text{ and } h_2(t) = \text{rect}\left(\frac{t-2}{4}\right)$$

If these systems are cascaded then response of the total system is

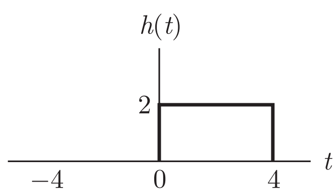
(A)



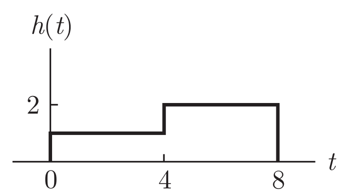
(B)



(C)



(D)



SOL 1.42 Option (B) is correct.

Response of the overall system is given as

$$h(t) = h_1(t) * h_2(t)$$
$$h(t) = [u(t) - u(t-4)] * \text{rect}\left(\frac{t-2}{4}\right)$$

$$\because \text{rect}\left(\frac{t-2}{4}\right) = u(t) - u(t-4) \text{ so}$$

$$h(t) = [u(t) - u(t-4)] * u(t) - u(t-4)$$
$$= [u(t) * u(t) - u(t) * 4(t-4) - u(t-4) * u(t) + u(t-4) * u(t-4)]$$

$$\because u(t) * u(t) = \text{ramp}(t)$$

so, $$h(t) = [\text{ramp}(t) - \text{ramp}(t-4) - \text{ramp}(t-4) + \text{ramp}(t-8)]$$
$$G(t) = \text{ramp}(t) - 2\text{ramp}(t-4) + \text{ramp}(t-8)$$

MCQ 1.43 Suppose we have given following information about a signal $x(t)$:

1. $x(t)$ is real and odd.
2. $x(t)$ is periodic with $T = 2$
3. Fourier coefficients $X[k] = 0$ for $|k| > 1$
4. $\frac{1}{2}\int_0^2 |x(t)|^2 dt = 1$

The signal, that satisfy these condition, is

(A) $\sqrt{2}\sin\pi t$ and unique (B) $\sqrt{2}\sin\pi t$ but not unique

(C) $2\sin\pi t$ and unique (D) $2\sin\pi t$ but not unique

SOL 1.43 Option (B) is correct.

Since $x(t)$ is real and odd, $X[k]$ is purely imaginary and odd. Therefore $X[k] =- X[-k]$ and $X[0] = 0$. Since $X\{k] = 0$ for $|k| > 1$, they only unknown coefficient are $X[1]$ and $X[-1]$

$$\frac{1}{T}\int_T |x(t)|^2 dt = \sum_{k=-\infty}^{\infty} |X[k]|^2$$

For $x(t)$, $$\frac{1}{2}\int_0^2 |x(t)|^2 dt = \sum_{k=-1}^{1} |X[k]|^2$$

$$\Rightarrow |X[1]|^2 + |X[-1]|^2 = 1,$$

$$2|X[1]|^2 = 1$$

$$X[1] =- X[-1] = \frac{j}{\sqrt{2}} \text{ or } X[1] =- X[-1] = \frac{-j}{\sqrt{2}}$$

Thus there are two solutions

$$x_1(t) = \frac{j}{\sqrt{2}} e^{j\left(\frac{2\pi}{2}\right)t} - \frac{j}{\sqrt{2}} e^{-j\left(\frac{2\pi}{2}\right)t} =- \sqrt{2}\sin\pi t$$

$$x_2(t) =- \frac{j}{\sqrt{2}} e^{j\left(\frac{2\pi}{2}\right)t} + \frac{j}{\sqrt{2}} e^{-j\left(\frac{2\pi}{2}\right)t} = \sqrt{2}\sin\pi t$$

MCQ 1.44 Four types of d.c. generators of constant speed are considered (**List I**). Their external characteristics at constant speed are given in **List II**. Match **List I** (Type of d.c. generator) with **List II** (External characteristics) and select the correct answer using the codes given below

List I

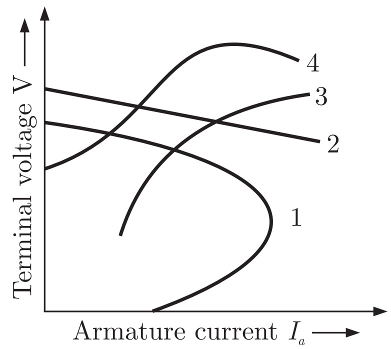
A. Separately excited

B. Series excited

C. Shunt excited

D. Over-compound excited

List II



Codes :

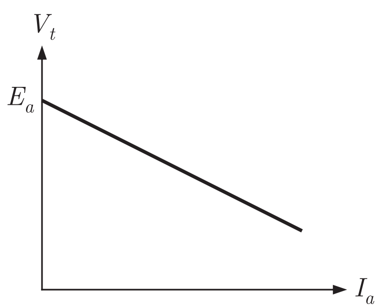
	A	B	C	D
(A)	2	3	1	4
(B)	1	4	2	3
(C)	1	3	2	4
(D)	2	4	1	3

SOL 1.44 Option (A) is correct.

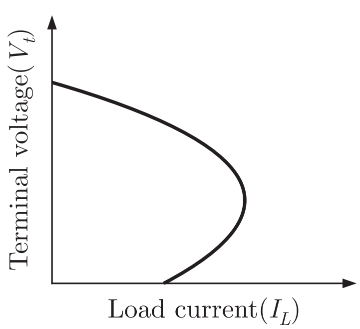
For a separately excited dc generator, terminal voltage is

$$V_t = E_a - I_a R_a$$

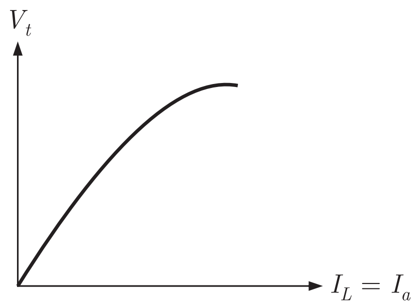
So the external characteristic is



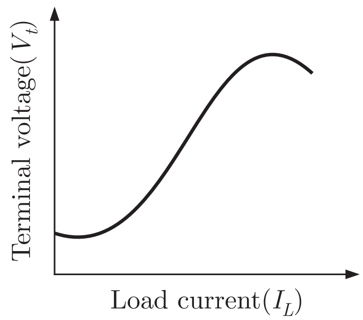
For a shunt generator



For a series excited generator



For over-compound generator



MCQ 1.45 A 480 V, 100 kW, 50 Hz, unity pf, six-pole star-connected synchronous motor is to be operated over a continuous range of speeds from 300 rpm to 1000 rpm. It has a synchronous reactance of 1.5 Ω and a negligible armature resistance. What is the value of generated voltage at 300 rpm ?

(A) 99.2 V (B) 168.4 V

(C) 330.6 V (D) 364.3 V

SOL 1.45 Option (A) is correct.

For speed of 300 rpm frequency is

$$f_1 = \frac{n_m P}{120} = \frac{300 \times 6}{120} = 15\text{ Hz}$$

For the speed of 1000 rpm frequency is

$$f_2 = \frac{n_m P}{120} = \frac{1000 \times 6}{120} = 50\text{ Hz}$$

The armature current at rated conditions is

$$I_a = \frac{100\text{ kW}}{\sqrt{3} \times 480 \times 1} = 120.3\text{ A}$$

The phase voltage is

$$V_t = 480/\sqrt{3} = 277\text{ V}$$

The internal generated voltage is

$$E_a = \sqrt{(V_t \cos\theta - I_a R_a)^2 + (V_t \sin\theta - I_a X_s)^2}$$

$$E_a = \sqrt{(277 \times 1 - 0)^2 + (277 \times 0 - 120.3 \times 1.5)^2}$$

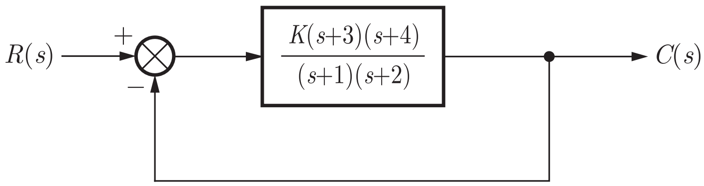
$$= 330.6\text{ V}$$

E_a decreases linearly with frequency, so at the speed of 300 rpm (i.e 15 Hz)

$$E_{a,300} = \frac{15\text{ Hz}}{50\text{ Hz}}(330.6) = 99.18\text{ V}$$

MCQ 1.46 For the *ufb* system, shown below consider two point

$$s_1 = -2 + j3 \text{ and } s_2 = -2 + j\frac{1}{\sqrt{2}}$$



The point on root locus are

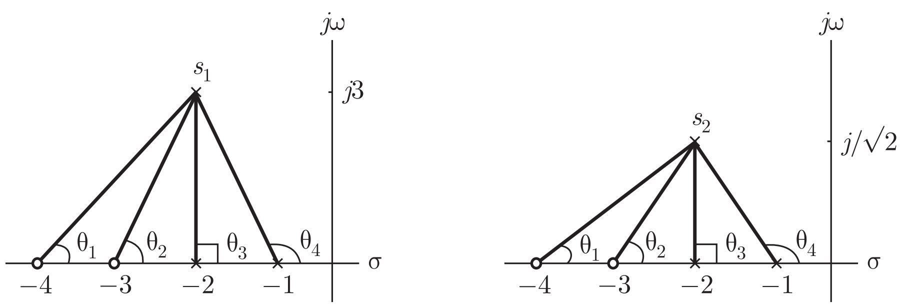
(A) Both s_1 and s_2

(B) s_1 but not s_2

(C) s_2 but not s_1

(D) neither s_1 nor s_2

SOL 1.46 Option (C) is correct.



For s_1,

$$\theta_1 + \theta_2 - \theta_3 - \theta_4 = \tan^{-1}\frac{3}{2} + \tan^{-1}\frac{3}{1} - 90^\circ - \left(180 - \tan^{-1}\frac{3}{1}\right)$$

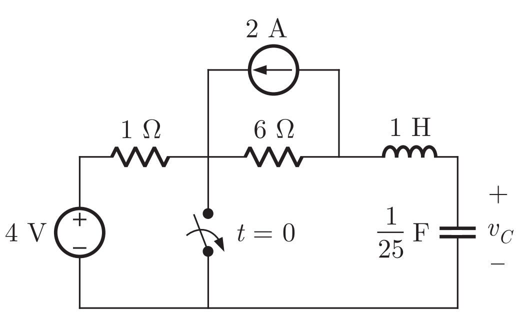
$$= +70.65^\circ, \text{ So } s_1 \text{ is not on root locus.}$$

For s_2,

$$\theta_1 + \theta_2 - \theta_3 - \theta_4 = \tan^{-1}\frac{1}{2\sqrt{2}} - 90^\circ$$

$$-\left(180 - \tan^{-1}\frac{1}{2\sqrt{2}}\right) = -180^\circ, \text{ So } s_2 \text{ in on root locus.}$$

MCQ 1.47 The switch is closed after long time in the circuit shown below. The $v(t)$ for $t > 0$ is



(A) $-8+6e^{-3t}\sin 4t$ V

(B) $-12+4e^{-3t}\cos 4t$ V

(C) $-12+(4\cos 4t+3\sin 4t)\,e^{-3t}$ V

(D) $-12+(4\cos 4t+6\sin 4t)\,e^{-3t}$ V

SOL 1.47 Option (C) is correct.

$$i_L(0^+) = 0,$$
$$v_L(0^+) = 4-12 = -8$$
$$\frac{1}{25}\frac{dv_L(0^+)}{dt} = i_L(0^+) = 0$$
$$\alpha = \frac{6}{2} = 3,$$
$$\omega_0 = \frac{1}{\sqrt{1\times 1/25}} = 5$$
$$\beta = -3 \pm \sqrt{9-25} = -3 \pm j4$$
$$v(t) = -12+(A\cos 4t + B\sin 4t)\,e^{-3t}$$
$$v_L(0) = -8 = 12 + A,$$

$\Rightarrow A = 4$

$$\frac{dv_L(0)}{dt} = 0 = -3A + 4B,$$

$\Rightarrow B = 3$

Statement for Question 48-49 :

A system is described by following equation

$$A = \begin{bmatrix} 0 & 1 \\ -3 & -6 \end{bmatrix},\ B = \begin{bmatrix} 0 \\ 1 \end{bmatrix},\ C = \begin{bmatrix} 1 & 1 \end{bmatrix}$$

MCQ 1.48 The steady state error due to step input is

(A) $\frac{2}{3}$ (B) $\frac{1}{3}$

(C) ∞ (D) 0

SOL 1.48 Option (A) is correct.

$$e_{step}(\infty) = 1 + CA^{-1}B,$$
$$A^{-1} = \begin{bmatrix} -2 & -\frac{1}{3} \\ 1 & 0 \end{bmatrix}$$
$$e_{step}(\infty)\ 1 + \begin{bmatrix} 1 & 1 \end{bmatrix}\begin{bmatrix} -2 & -\frac{1}{3} \\ 1 & 0 \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix} = 1 - \frac{1}{3} = \frac{2}{3}$$

MCQ 1.49 The steady state error due to ramp input is

(A) $\frac{1}{3}$ (B) $\frac{2}{3}$

(C) ∞ (D) 0

SOL 1.49 Option (C) is correct.

$$e_{ramp}(\infty) = \lim_{t \to \infty}[(1 + CA^{-1}B)t + C(A^{-1})^2 B]$$

$$1 + CA^{-1}B = \frac{2}{3},$$

$$e_{ramp}(\infty) = \lim_{t \to \infty}\left[\frac{2}{3}t + C(A^{-1})^2 B\right] = \infty$$

Statement for Q. 50-51

An alternator rated at 10 kV is protected by the balanced circulating current system. It has its neutral grounded through a resistance of $10\,\Omega$. The protective relay is set to operate when there is an out of balanced current of 1.8 A in the pilot wires, which are connected to the secondary windings of 1000/5 ratio current transformers.

MCQ 1.50 What is the percent winding which remains unprotected ?

(A) 62.36% (B) 37.64%

(C) 3.12% (D) 96.88%

SOL 1.50 Option (A) is correct.

The phase voltage of the alternator

$$= \frac{10000}{\sqrt{3}} = 5773 \text{ volts}$$

Let $x\%$ be the percent winding which remains unprotected. The voltage of the unprotected portion of the winding

$$V_{\text{unprotected}} = 5773\left(\frac{x}{100}\right)$$

Since the resistance in the neutral is 10 ohms the fault current will be

$$I_f = 5773\left(\frac{x}{100}\right)\left(\frac{1}{10}\right) \text{amp.}$$

The current in the pilot wires will be with a CT of 1000/5 amps ratio

$$I_{\text{pilot}} = 5773\left(\frac{x}{100}\right)\left(\frac{1}{10}\right)\left(\frac{5}{1000}\right) \text{amps}$$

and this current should be equal to 1.8 amps for the operation of the relay.

$$5773\left(\frac{x}{100}\right)\left(\frac{1}{10}\right)\left(\frac{5}{1000}\right) = 1.8$$

or $$5773x = 3.6 \times 10^5$$

$$x = \frac{36 \times 10^4}{5.773 \times 10^3} = 62.36\%$$

MCQ 1.51 The minimum value of the earthing resistance required to protect 80% of the winding is

(A) 12.82 Ω (B) 3.20 Ω

(C) 16.04 Ω (D) 2.07 Ω

SOL 1.51 Option (B) is correct.

To protect 80% of the winding, the unprotected portion is 20%. The voltage of the unprotected portion

$$V_{\text{unprotected}} = 5773 \times 0.2 = 1154.6 \text{ volts}$$

Let R be the minimum value of the earthing resistance; the fault current will be

$$I_f = \frac{1154.6}{R} \text{ amp}$$

The fault current through the pilot wire will be

$$I_f = \frac{1154.6}{R}\left(\frac{5}{1000}\right) \text{ amp}$$

This should equal the operating current of 1.8 amp

or $$\frac{1154.6}{R}\left(\frac{5}{1000}\right) = 1.8$$

or $$R = \frac{5 \times 1154.6}{1800} = 3.20\,\Omega$$

Statement for Q. 52-53 :

A 120 V, 2400 rpm dc shunt motor operates at its rated speed at full-load and draws 14.75 A current. The armature resistance is 0.4 Ω and shunt field resistance is 160 Ω. The no-load current is 2 A. An external resistance of 3.6 Ω is now inserted in series with the armature while the torque developed is unchanged.

MCQ 1.52 The no-load speed of the motor before adding the external resistance is

(A) 2297.5 rpm (B) 2300 rpm

(C) 2507 rpm (D) 2214 rpm

SOL 1.52 Option (C) is correct.

The field current $I_f = 120/160 = 0.75$ A

At no-load condition :

Armature current $I_{a,nL} = 2 - 0.75 = 1.25$ A

Induced Emf $E_{a,nL} = 120 - 1.25 \times 0.4 = 119.5$ V

The power developed at no load accounts for the rotational loss in the motor.

From full-load data :

Armature current $I_{a,fL} = 14.75 - 0.75 = 14$ A

Induced Emf $E_{a,fL} = 120 - 14 \times 0.4 = 114.4$ V

Speed $N_{fL} = 2400$ rpm

Hence, the no-load speed:

$$N_{nL} = N_{fL} \times \frac{E_{a,nL}}{E_{a,fL}}$$

$$= 2400 \times \frac{119.5}{114.4} \approx 2507 \text{ rpm}$$

MCQ 1.53 The full-load efficiency of the motor after adding the external resistance would be

(A) 42.2% (B) 46.1%

(C) 60.95% (D) 55.1%

SOL 1.53 Option (B) is correct.

With external resistance in the armature circuit and no change in the torque developed

Armature current $I_a = I_{a,fL} = 14$ A

Induced Emf $E_a = 120 - 14 \times (0.4 + 3.6) = 64$ V

Power developed $P_d = 64 \times 14 = 896$ W

Speed in this condition

$$N_m = N_{fL} \times \frac{E_{an}}{E_{a\,fL}}$$

$$= \frac{64}{114.4} \times 2400 \approx 1343 \text{ rpm}$$

Developed Power at no-load

$$P_{d,nL} = 119.5 \times 1.25 = 149.38 \text{ W}$$

Rotational loss after adding the external resistance

$$P_r = \frac{N_m}{N_{nL}} \times P_{d,nL}$$

$$= \frac{1343}{2507} \times 149.38 = 80 \text{ W}$$

The power output and the efficiency are

$$P_{out} = 896 - 80 = 816 \text{ W}$$

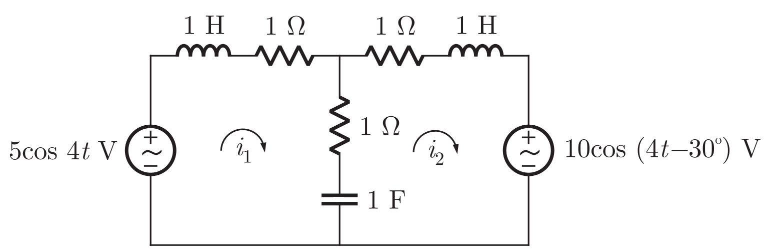
Input power $P_{in} = 14.75 \times 120 = 1770$ W

$$\eta = \frac{P_{out}}{P_{in}} \times 100$$

$$= \frac{816}{1770} \times 100 = 46.1\%$$

Statement for Q. 54-55:

The circuit is as shown below



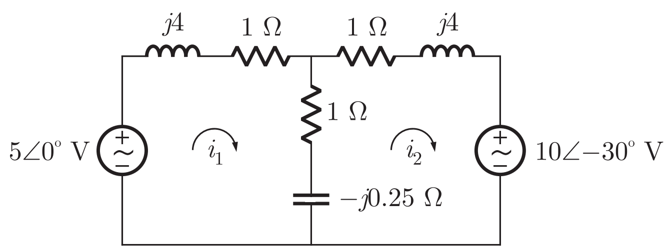
MCQ 1.54 In the circuit below the current $i_1(t)$ is

(A) $2.36\cos(4t - 41.07°)$ A (B) $2.36\cos(4t + 41.07°)$ A

(C) $1.37\cos(4t - 41.07^\circ)$ A (D) $2.36\cos(4t + 41.07^\circ)$ A

SOL 1.54 Option (C) is correct.

The circuit is as shown below



$$5\angle 0^\circ = i_1\left(j4 + 1 + 1 - \frac{j}{4}\right) - i_2\left(1 - \frac{j}{4}\right)$$

$$\Rightarrow \quad (8 + j15)\, i_1 - (4 - j)\, i_2 = 20\angle 0 \quad \text{...(i)}$$

$$-10\angle -30^\circ = i_2\left(1 + j4 + 1 - \frac{j}{4}\right) - i_1\left(1 - \frac{j}{4}\right)$$

$$\Rightarrow \quad (4 - j)\, i_1 - (8 + j15)\, i_2 = 40\angle -30^\circ \quad \text{...(ii)}$$

$$i_1[(8 + j15)^2 - (4 - j)^2] = (20\angle 0)(8 + j15) - (40\angle -30^\circ)(4 - j)$$

$$i_1(-176 + j248) = 41.43 + j414.64$$

$$\Rightarrow \quad i_1 = 1.03 - j0.9 = 1.37\angle -41.07$$

MCQ 1.55 In the circuit shown below the current $i_2(t)$ is

(A) $2.04\sin(4t + 92.13^\circ)$ A (B) $-2.04\sin(4t + 2.13^\circ)$ A

(C) $2.04\cos(4t + 2.13^\circ)$ A (D) $-2.04\cos(4t + 92.13^\circ)$ A

SOL 1.55 Option (A) is correct.

$$i_2 = \frac{(8 + j15)(1.03 - j0.9) - 20\angle 0^\circ}{4 - j}$$

$$= -0.076 + j2.04$$

$$\Rightarrow \quad i_2 = 2.04\angle 92.13^\circ$$

Q.56 TO Q.60 CARRY ONE MARK EACH

MCQ 1.56 Which one of the following is the Antonym of the word NULLIFY ?

(A) void (B) legitimize

(C) repose (D) indomitable

SOL 1.56 Correct option is (B)

MCQ 1.57 Which one of the following is the synonym of the word REPEAL ?

(A) sharp (B) applaud

(C) acceptance (D) abrogation

SOL 1.57 Correct option is (D)

MCQ 1.58 One of the four words given in the four options does not fit the set of words. The odd word from the group, is

(A) Cardigan (B) Pullover

(C) Tuxedo (D) Sweater

SOL 1.58 Correct option is (C)

MCQ 1.59 A pair of CAPITALIZED words shown below has four pairs of words. The pair of words which best expresses the relationship similar to that expressed in the capitalized pair, is

UNITY : DIVERSITY

(A) Single : Multiple (B) One : Many

(C) Homogeneous : Heterogeneous (D) Singular : Plural

SOL 1.59 Correct option is (C)

MCQ 1.60 In the following sentence, a part of the sentence is left unfinished. Four different ways of completing the sentence are indicated. The best alternative among the four, is

The interest generated by the soccer World Cup is...................compared to the way cricket................the nation.

(A) milder, fascinates (B) lukewarm, electrifies

(C) tepid, inspires (D) unusual, grips

SOL 1.60 Correct option is (B)

Q.61 TO Q.65 CARRY TWO MARK EACH

MCQ 1.61 What is the smallest integer k for which $64^k > 4^{14}$?

(A) 3 (B) 5

(C) 6 (D) 7

SOL 1.61 Correct option is (B).

If we don't want to do a lot of calculations, we're going to have to manipulate the exponents. The first step is to put the 64 and the 4 in the same terms, so let's make the $64 = 4^3$ instead. Now the question is looking for the smallest integer k for which $4^{3k} > 4^{14}$, which is the same as finding the smallest integer k for which $3k > 14$. The best answer is 5.

MCQ 1.62 The angles of a polygon are in arithmetic progression. If the smallest angle is 120° and the common difference is 10°, then how many sides does the polygon have ?

(A) 5 (B) 6

(C) 8 (D) Either (B) or (C)

SOL 1.62 Correct option is (B).

Smallest angle $= 120^0$, common difference $= 10^\circ$.

Maximum angle $= 170^\circ$ ($\because$ 180° is a straight line).

MCQ 1.63 A certain clock rings two notes at quarter past the hour, four notes at half past, and six notes at three-quarters past. On the hour, it rings eight notes plus an additional number of notes equal to whatever hour it is. How many notes will the clock ring between 2:00 P.M. and 5:00 P.M., including the rings at 2:00 and 5:00 ?

(A) 72 (B) 78

(C) 96 (D) 102

SOL 1.63 Correct option is (B).

We know that the problem involves only simple arithmetic, because the rings occur in an hourly pattern. You could set up a chart if that helps you see what's going on, or just take each part at a time by finding the number of rings at each interval of time and then adding up the total rings at each interval. The total rings on the hour $= (1+8)+(2+8)+(3+8)+(4+8) = 9+10+11+12 = 42$. The clock rings twice at a quarter past and it does this 3 times, so the total rings at a quarter past $= 2(3) = 6$. Likewise, the number of rings at half past $= 4(3) = 12$ and the number of rings at three-quarters past $= 6(3) = 18$. Adding up, $42+6+12+18 = 78$

MCQ 1.64 In an increasing sequence of 10 consecutive integers, the sum of the first 5 integers is 660. What is the sum of the last 5 integers in the sequence ?

(A) 578 (B) 624

(C) 665 (D) 685

SOL 1.64 Correct option is (D).

Let the first 5 consecutive integers be represented by x, $x+1$, $x+2$, $x+3$ and $x+4$. Then, since the sum of the integers is 660, $x+(x+1)+(x+2)+(x+3)+(x+4) = 660$. Thus,

$$5x+10 = 660$$

$$5x = 650 \qquad \text{solve for } x$$

$$x = 130$$

The first integer in the sequence is 130, so the next integers are 131, 132 , 133 and 134. From this, the last 5 integers in the sequence, and thus their sum, can be determined. The sum of the 6^{th}, 7^{th}, 8^{th}, 9^{th} and 10^{th} integers is, $135+136+137+138+139 = 685$

This problem can also be solved without algebra: The sum of the last 5 integers exceeds the sum of the first 5 integers by $1+3+5+7+9 = 25$ because the 6^{th}

MCQ 1.65 What will be the sum to n terms of the series $9+99+999+ ....$?

(A) $\frac{(10^n+1)}{9}$ (B) $\frac{10}{9}(10^n-1)$

(C) $\frac{10(10^n-1)}{9} - n$ (D) $\frac{10}{9}[(10^n-1)-n]$

SOL 1.65 Correct option is (C).

The series can be written as $\Sigma(10^n - 1)$.

$$= \Sigma 10^n - \Sigma 1 = \frac{10(10^n - 1)}{10 - 1} - n$$

Answer Key

1.	2.	3.	4.	5,	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
C	B	B	D	B	C	A	C	B	B	D	D	C	D	C
16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
C	D	B	D	C	C	D	B	C	C	A	A	C	C	D
31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.
A	D	B	D	A	A	A	C	D	A	B	B	B	A	A
46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
C	C	A	C	A	B	C	B	C	A	B	D	C	C	B
61.	62.	63.	64.	65.				.					.	
B	B	B	D	C										

Practice paper EE_E

Q. 1- Q. 25 carry one mark each.

MCQ 1.1 The median of 0, 2, 2, -3, 5, -1, 5, 5, -3, 6, 6, 5, 6 is

(A) 0 (B) -1.5

(C) 2 (D) 3.5

SOL 1.1 Option (D) is correct.

Observations in ascending order are -3, -3, -1, 0, 2, 2, 2, 5, 5, 5, 5, 6, 6, 6.

Number of observations is 14, which is even.

Median $= \frac{1}{2}[7 \text{ then term } + 8 \text{ the term}] = \frac{1}{2}(2+5) = 3.5$

MCQ 1.2 If $v = 2xy$, then the analytic function $f(z) = u + iv$ is

(A) $z^2 + c$ (B) $z^{-2} + c$

(C) $z^3 + c$ (D) $z^{-3} + c$

SOL 1.2 Option (A) is correct.

$$\frac{\partial v}{\partial x} = 2y = h(x,y), \frac{\partial v}{\partial y} = 2x = g(x,y)$$

by Milne's Method $f'(z) = g(z,0) + ih(z,0) = 2z + i0 = 2z$

On integrating $f(z) = z^2 + c$

MCQ 1.3 $\int \frac{dx}{e^x - 1}$ is equal to

(A) $\log(e^x - 1)$ (B) $\log(1 - e^x)$

(C) $\log(e^{-x} - 1)$ (D) $\log(1 - e^{-x})$

SOL 1.3 Option (D) is correct.

Let
$$I = \int \frac{dx}{e^x - 1} = \int \frac{e^{-x}\,dx}{1 - e^{-x}}$$
$$= \int \frac{dt}{t} \qquad \text{Putting } 1 - e^{-x} = t \Rightarrow e^{-x}dx = dt$$
$$= \log t = \log(1 - e^{-x})$$

MCQ 1.4 If Rolle's theorem holds for $f(x) = x^3 - 6x^2 + kx + 5$ on $[1,3]$ with $c = 2 + \frac{1}{\sqrt{3}}$, then value of k is

(A) -3 (B) 3

(C) 7 (D) 11

SOL 1.4 Option (D) is correct.

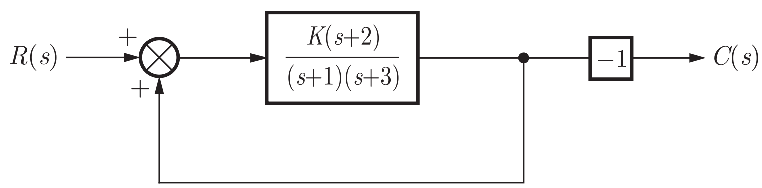
$$f'(x) = 3c^2 - 12x + k$$

$$f'(c) = 0 \Rightarrow 3c^2 - 12c + k = 0$$

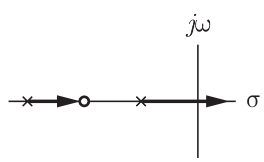
$$\Rightarrow \quad c = \frac{12 \pm \sqrt{144 - 12k}}{6} \Rightarrow \frac{144 - 12k}{36} = \frac{1}{3}$$

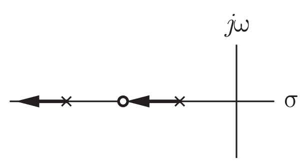
$$\Rightarrow \quad 144 - 12k = 12 \Rightarrow k = 11.$$

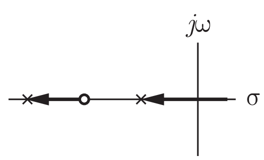
MCQ 1.5 Consider the feedback system shown below

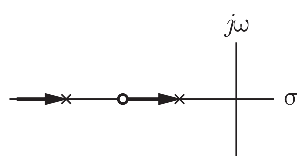


For this system root locus is

(A)


(B)


(C)


(D)


SOL 1.5 Option (A) is correct.

It is positive feedback system. So on real axis root locus will exist to the left of even number of pole and zeroes. Plot will start from pole and end on zeroes. Option (A) satisfies this condition.

MCQ 1.6 The forward-path transfer function of a *ufb* system is

$$G(s) = \frac{K(s^2 - 4)}{s^2 + 3}$$

For the system to be stable the range of K is

(A $K > -1$ (B) $K < \frac{3}{4}$

(C) $-1 < K < \frac{3}{4}$ (D) marginal stable

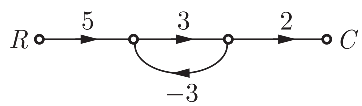
SOL 1.6 Option (D) is correct.

Closed loop transfer function

$$T(s) = \frac{K(s^2 - 4)}{(K+1)\,s^2 + (3 - 4K)}$$

The system can be only marginally stable.

MCQ 1.7 In the signal flow graph shown below the transfer function is



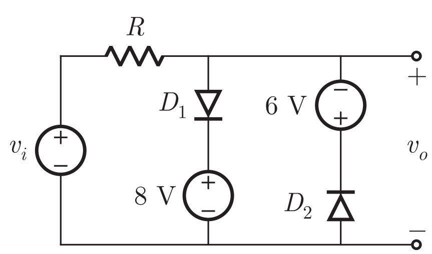
(A) 3.75 (B) −3

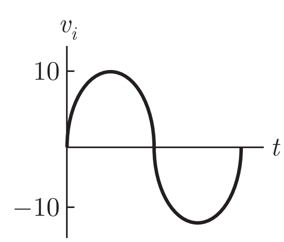
(C) 3 (D) −3.75

SOL 1.7 Option (C) is correct.

$$P_1 = 5 \times 3 \times 2 = 30,$$
$$\triangle = 1 - (3 \times -3) = 10, \quad \triangle_1 = 1,$$
$$\frac{C}{R} = \frac{30}{10} = 3$$

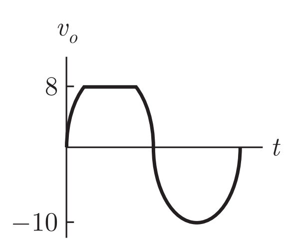
MCQ 1.8 Consider the given circuit and waveform for the input voltage. The diode in circuit has cutin voltage $V_\gamma = 0$.



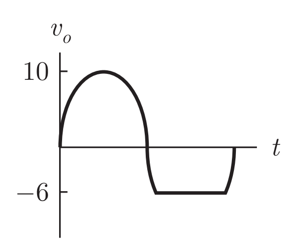


The waveform of output voltage v_o is

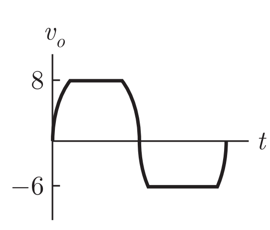
(A)



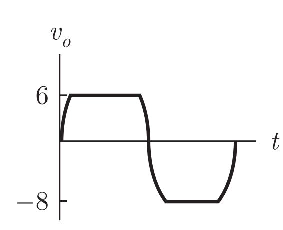
(B)



(C)



(D)



SOL 1.8 Option (C) is correct.

During positive cycle when $v_i < 8$ V, both diode are OFF $v_o = v_i$. For $v_i > 8$ V, $v_o = 8$ V, D_1 is ON. During negative cycle when $|v_i| < 6$ V, both diode are OFF, $v_o = v_i$. For $|v_i| > 6$ V, D_2 is on $v_o = -6$ V.

MCQ 1.9 If $(211)_x = (152)_8$, then the value of base x is

(A) 6 (B) 5

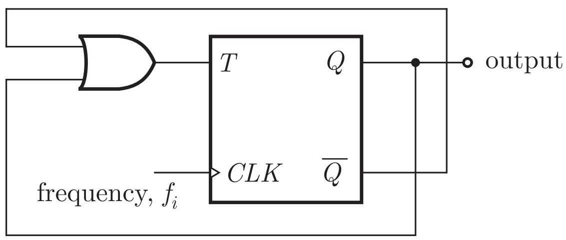
(C) 7 (D) 9

SOL 1.9 Option (C) is correct.

$$2x^2 + x + 1 = 64 + 5 \times 8 + 2$$

$$\Rightarrow \quad x = 7$$

MCQ 1.10 In the following circuit, Initially flip flop is cleared. If input clock frequency is f_i, then frequency at output will be



(A) $2f_i$ (B) $\frac{f_i}{2}$

(C) $4f_i$ (D) will be same as input

SOL 1.10 Option (B) is correct.

Here T is, $T = Q_n + \overline{Q}_n \Rightarrow T = 1$ (always)

So, output will toggle at each clock pulse.

The output sequence is 010101010...

Frequency of output is $\frac{f_i}{2}$

MCQ 1.11 The conduction loss versus device current characteristic of a power MOSFET is best approximated by

(A) a parabola

(B) a straight line

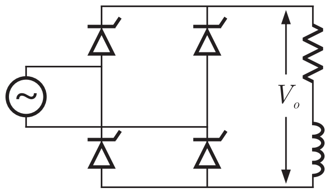
(C) a rectangular hyperbola

(D) an exponentially decaying function

SOL 1.11 Option (A) is correct.

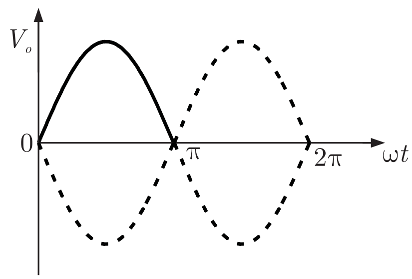
The conduction loss v/s MOSFET current characteristics of a power MOSFET is best approximated by a parabola.

MCQ 1.12 A single-phase half controlled converter shown in the figure feeding power to highly inductive load. The converter is operating at a firing angle of 60°.

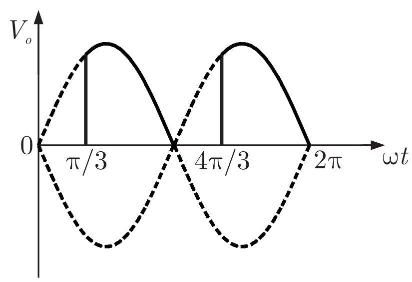


If the firing pulses are suddenly removed, the steady state voltage (V_0) waveform of the converter will become

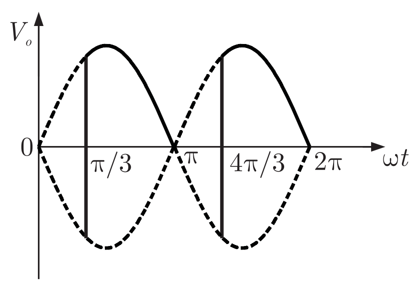
(A)



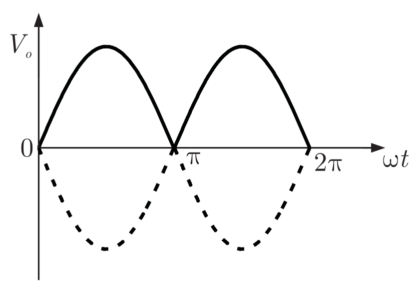
(B)



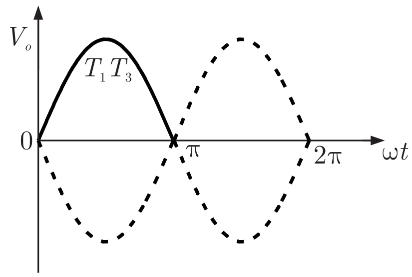
(C)



(D)

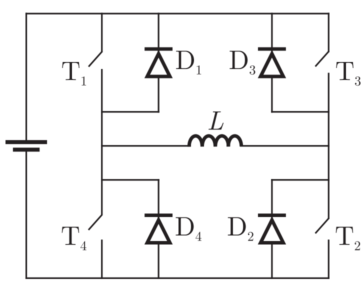


SOL 1.12 Option (A) is correct.
Output of this



Here the inductor makes T_1 and T_3 in ON because current passing through T_1 and T_3 is more than the holding current.

MCQ 1.13 A single-phase full bridge voltage source inverter feeds a purely inductive load as shown in figure, where T_1, T_2, T_3, T_4 are power transistors and D_1, D_2, D_3, D_4 are feedback diodes. The inverter is operated in square-wave mode with a frequency of 50 Hz. If the average load current is zero, what is the time duration of conduction of each feedback diode in a cycle?



(A) 5 msec (B) 10 msec

(C) 20 msec (D) 2.5 msec

SOL 1.13 Option (D) is correct.

$$\because \qquad f = 50 \text{ Hz}$$

$$\text{So total time} = \frac{1}{f} = \frac{1}{50} = 20 \text{ msec}$$

Conduction time for each feedback diode in a cycle is being given by

$$t_{conduction} = \frac{20}{8} = 2.5 \text{ msec}$$

MCQ 1.14 Wagner Earth devices in AC bridge circuits are used for

(A) Shielding all the bridge elements from external magnetic field

(B) Eliminating the effect of stray capacitance

(C) Minimizing the effect of inter-component capacitance

(D) Eliminating all the node to earth capacitances

SOL 1.14 Option (D) is correct.

Wagner earth connection eliminates the capacitance existing between the detector terminal and ground.

MCQ 1.15 A Lissajou pattern observed on an oscilloscope is stationary and has 5 horizontal tangencies and 2 vertical tangencies. If the frequency of horizontal input is 1,000 Hz, then frequency of vertical input is

(A) 2500 Hz (B) 500 Hz

(C) 400 Hz (D) 2000 Hz

SOL 1.15 Option (A) is correct.

Frequency of vertical input

$$f_y = f_x \times \frac{\text{Horizontal tangencies}}{\text{Vertical tangencies}}$$

Where f_x is the frequency of horizontal input

$$f_y = 1{,}000 \times \frac{5}{2} = 2{,}500\,\text{Hz}$$

MCQ 1.16 The errors introduced by an instrument fall in which category ?

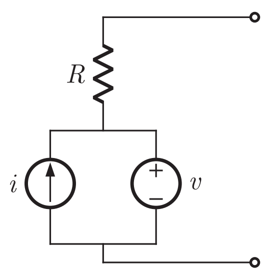
(A) Systematic errors (B) Random errors

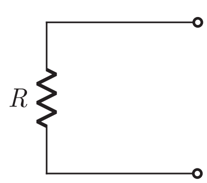
(C) Gross errors (D) Environmental errors

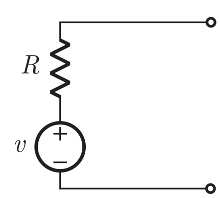
SOL 1.16 Option (A) is correct.

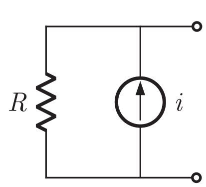
Systematic errors may be instrumental error, environmental error or observational errors.

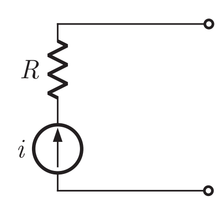
MCQ 1.17 A simple equivalent circuit of the 2 terminal network shown in figure is



(A)


(B)


(C)


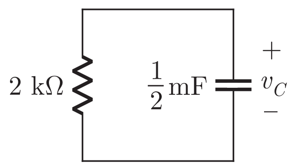
(D)


SOL 1.17 Option (B) is correct.

After killing all source equivalent resistance is R

Open circuit voltage $= v_1$

MCQ 1.18 In the following RC circuit the value of $v_C(0) = 10\text{ V}$, then the value of $v_C(t)$ is



(A) e^{-t} V (B) $5e^{-t}$ V

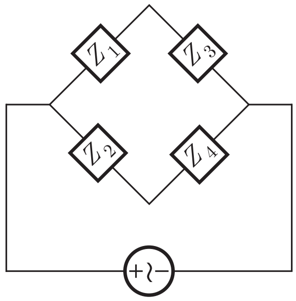
(C) $10e^{-t}$ V (D) $10 + e^{-t}$ V

SOL 1.18 Option (C) is correct.

$$v_C(t) = v_C(\infty) + [v_C(0) - v_C(\infty)]\, e^{-\frac{t}{RC}}$$

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

MCQ 1.19 In the bridge shown below $Z_1 = 300\,\Omega$, $Z_2 = (300 - j\,600)\,\Omega$, $Z_3 = (200 + j\,100)\,\Omega$. The Z_4 at balance is



(A) $400 + j\,300\,\Omega$ (B) $400 - j300\,\Omega$

(C) $j100\,\Omega$ (D) $-j900\,\Omega$

SOL 1.19 Option (B) is correct.

$$Z_1 Z_4 = Z_3 Z_2$$

$$300 Z_4 = (300 - j600)(200 + j100)$$

$$\Rightarrow \quad Z_4 = 400 - j300\ \Omega$$

MCQ 1.20 The Laplace transform of signal $u(t+2)$ is

(A) $\frac{1}{s}$ (B) $-\frac{1}{s}$

(C) $\frac{e^{-2s}}{s}$ (D) $\frac{-e^{-2s}}{s}$

SOL 1.20 Option (A) is correct.

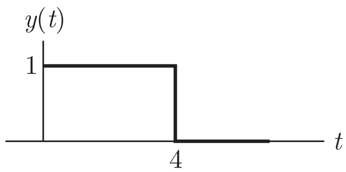
$$X(s) = \int_0^\infty x(t)\, e^{-st}\, dt = \int_0^\infty u(t+2)\, e^{-st}\, dt$$

$$= \int_0^\infty e^{-st}\, dt = \frac{1}{s}$$

MCQ 1.21 A Fourier transform pairs is as following

$$x(t) \overset{F}{\longleftrightarrow} X(j\omega) = \frac{2\sin\omega}{\omega} \text{ where } x(t) = \begin{cases} 1, & |t| < 1 \\ 0, & \text{otherwise} \end{cases}$$

The Fourier transform of signal shown below is



(A) $\frac{e^{j2\omega}\sin 2\omega}{2\omega}$ (B) $\frac{e^{-j2\omega}\sin 2\omega}{\omega}$

(C) $\frac{4e^{-j2\omega}\sin\frac{\omega}{2}}{\omega}$ (D) $\frac{4e^{j2\omega}\sin\frac{\omega}{2}}{\omega}$

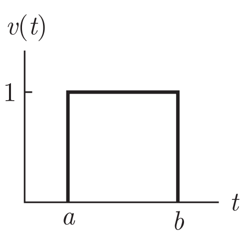
SOL 1.21 Option (B) is correct.

$$y(t) = x\left(\frac{t-2}{2}\right) \Rightarrow Y(j\omega) = e^{-j2\omega}X(j2\omega)$$

$$\Rightarrow \qquad Y(j\omega) = \frac{e^{-j2\omega}2\sin 2\omega}{2\omega}$$

$$= \frac{e^{-j2\omega}\sin 2\omega}{\omega}$$

MCQ 1.22 Consider the following function for the rectangular voltage pulse shown below



(1) $v(t) = u(a-t) \times u(t-b)$

(2) $v(t) = u(b-t) \times u(t-a)$

(3) $v(t) = u(t-a) - u(t-b)$

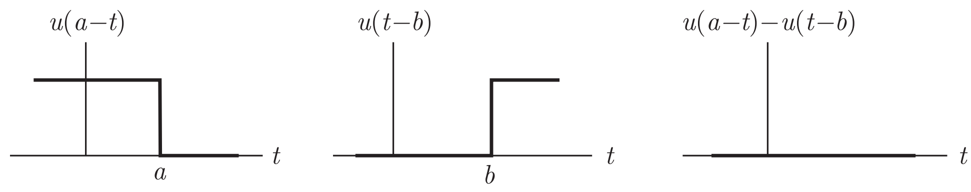
The function that describe the pulse are

(A) 1, and 2 (B) 2 and 3

(C) 1 and 3 (D) all

SOL 1.22 Option (B) is correct.

The function 1 does not describe the given pulse. It can be shown as follows :



MCQ 1.23 A single phase transformer has 350 and 700 turns in its primary and secondary winding. The primary is connected to a 400 V, 50 Hz ac supply. If the net cross-sectional area of core is 50 cm^2, the maximum value of flux density in the core is

(A) 51.48 T (B) 2.57 T

(C) 1.03 T (D) can not be determined

SOL 1.23 Option (C) is correct.

Emf

$$E_1 = 4.44 B_m \times A_c \times f \times N_1 \text{ volts}$$

or $$400 = 4.44 \times B_m \times 50 \times 10^{-4} \times 50 \times 350$$

so $$B_m = 1.0296 \text{ T}$$

MCQ 1.24 ACSR conductor implies

(A) aluminium conductor steel reinforced.

(B) all conductors surface treated and realigned.

(C) anodised core steel reinforced.

(D) none of the above.

SOL 1.24 Option (A) is correct.

ASCR implied Aluminium Conductor Steel Reinforced conductor which are mostly used in overhead transmission lines.

MCQ 1.25 Which of the following is true about the sequence reactance of transformer ?

(A) Negative and positive sequence reactances are equal to the leakage reactance.

(B) Negative sequence reactance is larger than the positive sequence reactance.

(C) Negative sequence reactance is smaller than the positive sequence reactance.

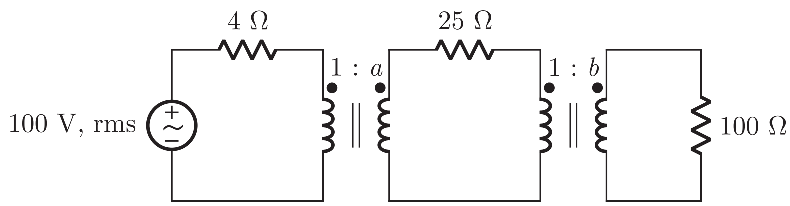
(D) None of above

SOL 1.25 Option (A) is correct.

The positive sequence impedance of a transformer is equal to its leakage reactance. Transformer is a static device so the leakage impedance does not change with changes in phase sequence of appliead voltages. Thus the negative sequence impedance is also equal to its leakage reactance.

Q. 26- Q. 55 carry two marks each.

MCQ 1.26 Consider the circuit shown below :



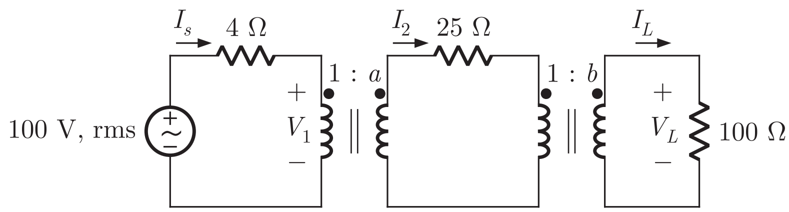
If the ideal source supplies 1000 W, half of which is delivered to the 100 Ω load, the value of a and b are

(A) 6, 0.47 (B) 5, 0.89

(C) 0.89, 5 (D) 0.47, 6

SOL 1.26 Option (B) is correct.

The circuit is as shown below



$$I_L = \sqrt{\frac{500}{100}} = \sqrt{5}\ \text{A},$$

$$V_L = 100\sqrt{5}\ \text{V}$$

$$I_s = \frac{1000}{100} = 10\ \text{A},$$

$$V_1 = 100 - 4 \times 10 = 60\ \text{V}$$

$$P_{25\,\Omega} = 1000 - 500 - 10^2 \times 4 = 100\ \text{W}$$

$$I_2 = \sqrt{\frac{100}{25}} = 2\ \text{A},$$

$$I_2 = bI_1$$

$$I_2 = b\sqrt{5} = 2,$$

$$b = \frac{2}{\sqrt{5}} = 0.89$$

In center mesh, $aV_1 = 25I_2 + \frac{V_L}{b}$

$$60a = 2 \times 25 + \frac{100\sqrt{5}}{d/\sqrt{5}} \Rightarrow a = \frac{300}{60} = 5$$

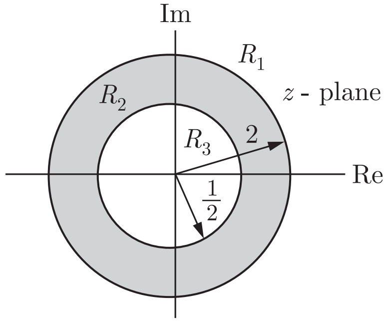
MCQ 1.27 Consider three different signal

$$x_1[n] = \left[2^n - \left(\frac{1}{2}\right)^n\right]u[n]$$

$$x_2[n] = -2^n u[-n-1] + \frac{1}{2^n}u[-n-1]$$

$$x_3[n] = -2^n u[-n-1] - \frac{1}{2^n}u[n]$$

Following figure shows the three different region. Choose the correct for the ROC of signal



	R_1	R_2	R_3
(A)	$x_1[n]$	$x_2[n]$	$x_3[n]$
(B)	$x_2[n]$	$x_3[n]$	$x_1[n]$
(C)	$x_1[n]$	$x_3[n]$	$x_2[n]$
(D)	$x_3[n]$	$x_2[n]$	$x_1[n]$

SOL 1.27 Option (C) is correct.

$x_1[n]$ is right-sided signal

$z_1 > 2, z_1 > \frac{1}{2}$ gives $z_1 > 2$

$x_2[n]$ is left-sided signal

$z_2 < 2, z_2 < \frac{1}{2}$ gives $z_2 < \frac{1}{2}$

$x_3[n]$ is double sided signal

$z_3 > \frac{1}{2}$ and $z_3 < 2$ gives $\frac{1}{2} < z_3 < 2$

MCQ 1.28 A 220 V dc shunt motor takes 5 A current on no load while running at a speed of 1000 rpm. It has an armature and a shunt field resistance of 0.3 Ω and 200 Ω respectively. Now the motor is driving a load drawing 40 A current from the supply. If the armature reaction weakens the field by 2.5% on this load, what would be speed of the motor ?

Assume magnetic circuit to be unsaturated.

(A) 954 rpm (B) 976 rpm

(C) 1023 rpm (D) 238.5 rpm

SOL 1.28 Option (B) is correct.

At no load

Load Current $I_{nL} = 5\text{ A}$

Field current $I_{f,nL} = \frac{220}{200} = 1.1\text{ A}$

Armature current $I_{a,nL} = I_{nL} - I_{f,nL} = 5 - 1.1 = 3.9\text{ A}$

Back emf $E_{a,nL} = V_t - I_{a,nL} R_a$

$= 220 - 3.9 \times 0.3 = 218.83\text{ V}$

At load

Load current $I_L = 40\text{ A}$

When the load is connected field current would be reduced by 2.5%, so I_f is taken as 1.0725 A (2.5% less) instead of 1.1 A.

Field current $I_f = 1.0725\text{ A}$

Armature current $I_a = I_L - I_f = 38.9\text{ A}$

Back emf $E_a = V_t - I_a R_a$

$$= 220 - 38.9 \times 0.3 = 208.33\text{ V}$$

$$\frac{E_a}{E_{a,nL}} = \frac{I_f \times n}{I_{f,nL} \times n_{nL}}$$

or $$n = n_0 \times \frac{I_{f,nL}}{I_f} \times \frac{E_a}{E_{a,nL}}$$

$$= 1{,}000 \times \frac{1.1}{1.0725} \times \frac{208.33}{218.33} = 976\text{ rpm}$$

MCQ 1.29 An industrial system has a load of 100 kVA at 0.6 pf lagging. A synchronous motor is added to the system to improve the overall power factor. If the synchronous motor is operating at 10 kW and 0.5 pf leading, then the overall power factor of the system is

(A) 0.58 (lagging) (B) 0.74 (lagging)

(C) 0.99 (leading) (D) 0.39 (leading)

SOL 1.29 Option (B) is correct.

For the plant

$$\theta_P = \cos^{-1}(0.6) = 53.13^\circ\text{ (lag)}$$

Complex power

$$S_P = 100\angle 53.13^\circ = 60 + j80\text{ kVA}$$

For the synchronous motor

$$\theta_m = \cos^{-1}(0.5) = 60^\circ\text{ (lead)}$$

$$|S_m| = \frac{10}{0.5} = 20\text{ kVA}$$

Thus, $S_m = 20\angle -60^\circ = 10 - j17.32\text{ kVA}$

The overall power requirements are

$$S_{total} = S_P + S_m$$

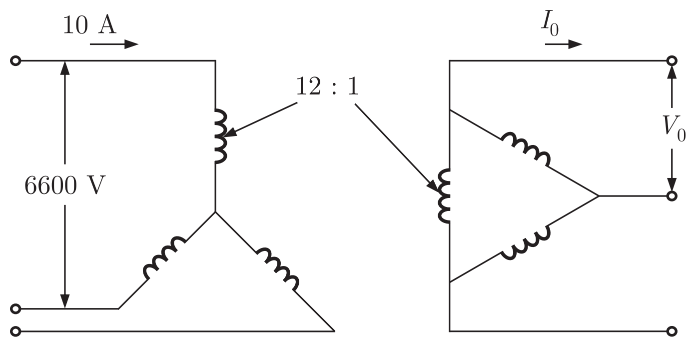
$$= 60 + 10 + j(80 - 17.32)$$

or $S_{total} = 93.96\angle 41.84^\circ\text{ kVA}$

and the power factor is

$$pf = \cos(41.84^\circ) = 0.74\text{ lagging}$$

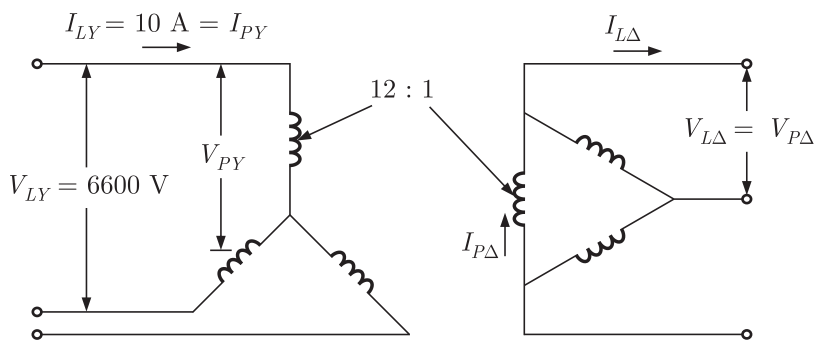
MCQ 1.30 Three single-phase transformer are connected in $Y - \Delta$ to form a 3-phase transformer bank as shown in the figure. It is used to step-down the voltage of a 3-phase, 6600 V transformer line. If the primary line current is 10 A and the turns ratio is 12, the output kVA will be



(A) 66
(B) 198
(C) 38.1
(D) 114.3

SOL 1.30 Option (D) is correct.

As shown on the figure



Phase voltage on primary side (Y)

$$V_{PY} = \frac{6600}{\sqrt{3}} \text{ V}$$

On the secondary side (Δ) line voltage and phase voltage will be same that is

$$V_{P\Delta} = V_{L\Delta} = \frac{6600}{\sqrt{3} \times 12} \text{ V}$$

Phase current on secondary side

$$I_{P\Delta} = 10 \times 12 = 120 \text{ A}$$

Line current on secondary side

$$I_{L\Delta} = 120\sqrt{3} \text{ A}$$

$$\text{Output kVA} = \sqrt{3} \times \frac{6600}{\sqrt{3} \times 12} \times 120\sqrt{3}$$

$$= 66\sqrt{3} = 114.3 \text{ kVA}$$

MCQ 1.31 A 120 V, 60 Hz capacitor start motor has the following impedances for the main and auxiliary windings at stand still

Main winding $Z_{\text{main}} = 4.5 + j3.7\,\Omega$

Auxiliary winding $Z_{\text{aux}} = 9.5 + j3.5\,\Omega$

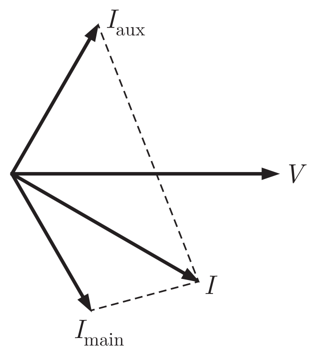
The value of starting capacitance that will place the main and auxiliary winding current in quadrature at starting is

(A) 177 μF (B) 610 μF

(C) 15 μF (D) 125 μF

SOL 1.31 Option (A) is correct.

The current I_{main} and I_{aux} are shown in the following figure



The impedance angle of the main winding is

$$\phi_{main} = \tan^{-1}\left(\frac{3.7}{4.5}\right) = 39.6^\circ$$

To produce 90° phase difference between the currents in the main and auxiliary winding, the impedance angle of the auxiliary winding circuit (including the starting capacitor) must be

$$\phi = 39.6^\circ - 90.0^\circ = -50.4^\circ$$

The combined impedance of the auxiliary winding and starting capacitor is equal to

$$Z_{total} = Z_{aux} + jX_C = 9.5 + j(3.5 + X_C)\,\Omega$$

Where $X_C = -\frac{1}{\omega C}$ is the reactance of the capacitor to be added.

$$\tan^{-1}\left(\frac{3.5 + X_C}{9.5}\right) = -50.4^\circ$$

$$\frac{3.5 + X_C}{9.5} = \tan(-50.4^\circ) = -1.21$$

or $$X_C = -1.21 \times 9.5 - 3.5 = -15.0\,\Omega$$

The capacitance C is then

$$C = \frac{-1}{\omega X_C} = \frac{-1}{377 \times (-15.0)} = 177\,\mu\text{F}$$

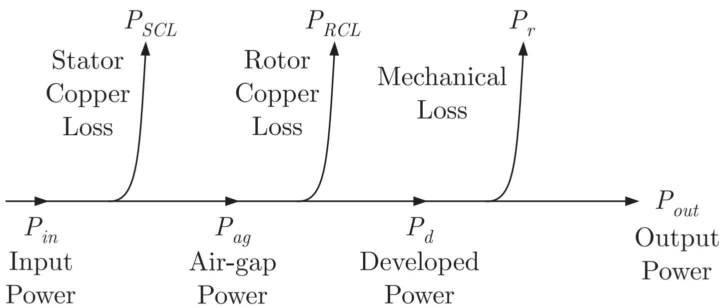
MCQ 1.32 A 50 Hz, 3-phase, 4 pole, induction motor operating at 4% slip draws 40 kW of power. The stator copped-loss and the the mechanical losses are 1.5 kW and 0.8 kW respectively. What is the efficiency of the motor ?

(A) 94.25% (B) 90.4%

(C) 92.4% (D) 36.25%

SOL 1.32 Option (B) is correct.

The power flow diagram is



Air-gap power $P_{ag} = P_{in} - P_{SCL}$

$= 40\,\text{kW} - 1.5\,\text{kW} = 38.5\,\text{kW}$

Rotor copper loss $P_{RCL} = sP_{ag}$

$= 0.04 \times 38.5 = 1.54\,\text{kW}$

Developed power $P_d = P_{ag} - P_{RCL}$

$= 38.5 - 1.54 = 36.96\,\text{kW}$

$P_{out} = P_d - P_r$

$= 36.96 - 0.8 = 36.16\,\text{kW}$

Efficiency $\eta = \dfrac{P_{out}}{P_{in}} = \dfrac{36.16}{40} = 0.904$

MCQ 1.33 A balanced delta-load having a resistance of $15\,\Omega$ per phase is in parallel with a balanced star-load having phase impedances of $8 + j6\,\Omega$. The combined load is supplied from a 110 V three-phase supply through three lines having impedance of $2 + j5\,\Omega$ each.

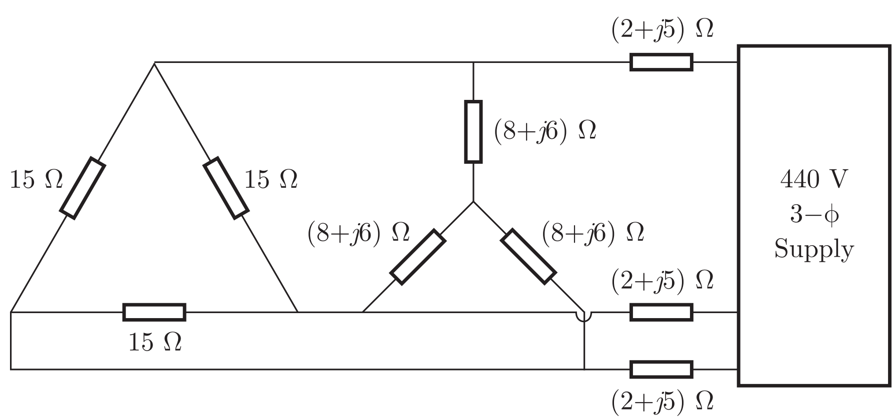
What is the value of line voltage at the combined loads ?

(A) 28.13 V (B) 48.72 V

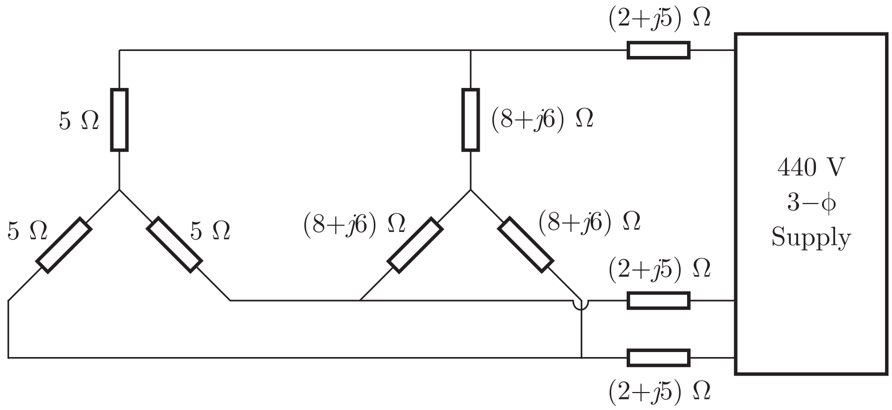
(C) 84.32 V (D) 16.24 V

SOL 1.33 Option (B) is correct.

Given circuit



Convert delta-to-star(i.e in star each impedance is $15/3 = 5\,\Omega$/phase)



Impedances in parallel per phase

$$\frac{5(8+j6)}{5+8+j6} = \frac{40+j30}{13+j6} \times \frac{13-j6}{13-j6} = \frac{700+j50}{205}$$

$$= 3.41 + j0.732 = 3.49\angle 12.1^\circ\ \Omega$$

Total impedance per phase

$$Z = 2 + j5 + 3.41 + j0.73$$

$$= 5.41 + j5.73 = 7.88\angle 46.65^\circ\ \Omega$$

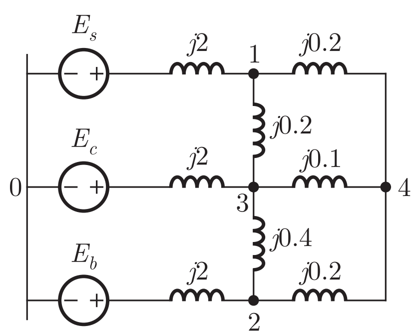
Current drawn at supply

$$|I| = \frac{110/\sqrt{3}}{7.88} = 8.06\ \text{A}$$

Line-to-line voltage

$$V_2 = \sqrt{3} \times 8.06 \times 3.49 = 48.72\ \text{V}$$

MCQ 1.34 The reactance diagram of a system is shown in figure. The bus admittance matrix Y_{BUS} for the system is



(A) $Y_{BUS} = j\begin{bmatrix} -10.5 & 0 & 5.0 & 5.0 \\ 0 & -8.0 & 2.5 & 5.0 \\ 5.0 & 2.5 & -18.0 & 10.0 \\ 5.0 & 5.0 & 10.0 & -20.0 \end{bmatrix}$

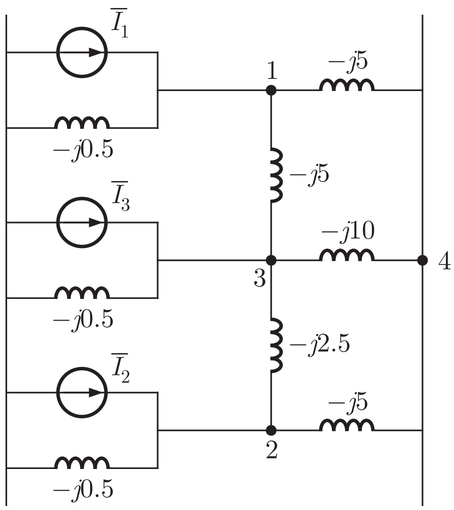
(B) $Y_{BUS} = j\begin{bmatrix} 0.724 & 0.620 & 0.656 & 0.644 \\ 0.620 & 0.738 & 0.642 & 0.660 \\ 0.656 & 0.642 & 0.702 & 0.676 \\ 0.684 & 0.660 & 0.676 & 0.719 \end{bmatrix}$

(C) $Y_{BUS} = j\begin{bmatrix} -10.5 & 0 & 5.0 & 0 \\ 0 & -8.0 & 0 & 5.0 \\ 5.0 & 0 & -18.0 & 10.0 \\ 5.0 & 5.0 & 10.0 & 0 \end{bmatrix}$

(D) $Y_{BUS} = j\begin{bmatrix} -10 & 0 & 0.5 & 0.5 \\ 0 & -2.5 & 8 & 0.5 \\ 0.5 & j8 & -0.18 & 0.1 \\ 0.5 & 0.5 & 0.1 & -0.5 \end{bmatrix}$

SOL 1.34 Option (A) is correct.

The admittance diagram is shown below:



$$Y_{11} = -j0.5 - j5 - j5 = -j10.5;$$
$$Y_{22} = -j0.5 - j2.5 - j5 = -j8.0$$
$$Y_{33} = -j0.5 - j5 - j10 - j2.5 = -j18.0;$$
$$Y_{44} = -j5 - j10 - j5 = -j20.0$$
$$Y_{12} = \overline{Y}_{21} = 0;\ Y_{13} = Y_{31} = j5.0;\ \overline{Y}_{14} = \overline{Y}_{41} = j5.0$$
$$Y_{23} = Y_{32} = j2.5;\ Y_{24} = Y_{42} = j5;\ Y_{34} = Y_{43} = j10.0$$

Hence the bus admittance matrix is given by

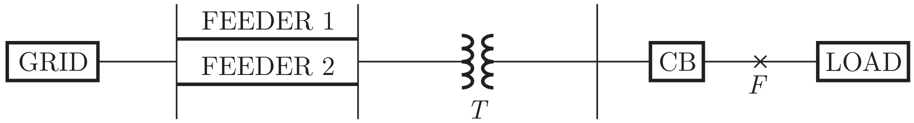
$$Y_{BUS} = \begin{bmatrix} -j10.5 & 0 & j5.0 & j5.0 \\ 0 & -j8.0 & j2.5 & j5.0 \\ j5.0 & j2.5 & -j18.0 & j10.0 \\ j5.0 & j5.0 & j10.0 & -j20.0 \end{bmatrix}$$

MCQ 1.35 In the system shown in figure, consider the grid as an infinite bus. The specifications are given as following

Transformer : 3-phase, 33/11 kV, 6 MVA, $0.01 + j0.08$ pu impedance

Load : 3-phase, 11 kV, 5,800 kVA, 0.8 lag, $j0.2$ pu impedance

Feeder : Impedance of $9 + j18\,\Omega$ each



What is the required MVA rating of circuit breaker on 6 MVA base ?

(A) 17.75 MVA
(B) 44.72 MVA
(C) 0.80 MVA
(D) 33.46 MVA

SOL 1.35 Option (B) is correct.

Let the base MVA is 6 MVA.

Per-unit impedance of transformer

$$X_T = 0.01 + j0.08$$

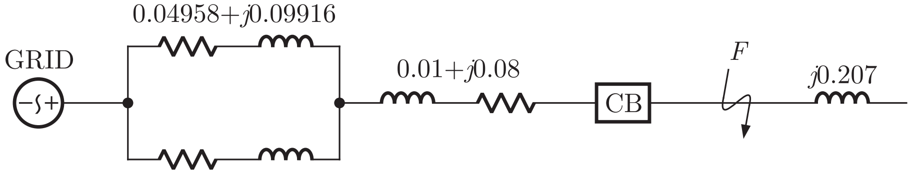
Per-unit impedance of each feeder

$$X_F = \frac{(9 + j18) \times 6}{(33)^2} = (0.04958 + j0.09916)\,\text{pu}$$

Per-unit impedance of load

$$X_L = \frac{j0.2 \times 6}{5.8} = j0.207$$

Thus, equivalent impedance diagram of the system is shown below



Equivalent impedance upto fault point

$$Z_{eq(\text{pu})} = \left[(0.04958 + j0.09916) \parallel (0.04958 + j0.09916)\right] + (0.01 + j0.08)$$
$$= (0.02479 + j0.04958) + (0.01 + j0.08)$$
$$Z_{eq(\text{pu})} = (0.03479 + j0.12958) = 0.13417\angle 74.97^\circ\ \text{pu}$$

Short-circuit rating of circuit breaker

$$= \frac{\text{Base MVA}}{Z_{eq(\text{pu})}} = \frac{6}{0.13417} = 44.72\,\text{MVA}$$

MCQ 1.36 A 500 MW, 21 kV, 50 Hz, 3-phase, 2-pole synchronous generator having a rated pf $= 0.9$, has a moment of inertia of 27.5×10^3 kg-m^2 .The inertia constant (H) will be

(A) 2.44 s
(B) 2.71 s
(C) 4.88 s
(D) 5.42 s

SOL 1.36 Option (A) is correct.

Given Synchronous generator of 500 MW, 21 kV, 50 Hz, 3-ϕ, 2-pole

pf $= 0.9$, Moment of inertia $M = 27.5 \times 10^3$ kg-m^2

Inertia constant $H = ?$

Generator rating in MVA

$$G = \frac{P}{\cos\phi} = \frac{500\text{ MW}}{0.9} = 555.56\text{ MVA}$$

$$N = \frac{120\times f}{\text{pole}} = \frac{120\times 50}{2} = 3000\text{ rpm}$$

$$\text{Stored K.E} = \frac{1}{2}M\omega^2 = \frac{1}{2}M\left(\frac{2\pi N}{60}\right)^2$$

$$= \frac{1}{2}\times 27.5\times 10^3\times\left(\frac{2\pi\times 3000}{60}\right)\text{MJ}$$

$$= 1357.07\text{ MJ}$$

$$\text{Inertia constant } (H) = \frac{\text{Stored K.E}}{\text{Rating of Generator (MVA)}}$$

$$H = \frac{1357.07}{555.56}$$

$$= 2.44\text{ sec}$$

MCQ 1.37 The forward-path transfer function of a *ufb* system is

$$G(s) = \frac{K(s+2)}{(s^2+1)(s+4)(s-1)}$$

The range of K, that will make the system stable, is

(A) $-12 < K < 2$

(B) $-33 < K < 2$

(C) $K > 2$

(D) Unstable

SOL 1.37 Option (D) is correct.

$$T(s) = \frac{K(s+2)}{s^4+3s^3-3s^2+(K+3)s+(2K-4)}$$

Routh table is shown below

s^4	1	-3	$2K-4$
s^3	3	$K+3$	
s^2	$-\frac{(K+12)}{3}$	$2K-4$	
s^1	$\frac{K(K+33)}{K+12}$		
s^0	$2K-4$		

$$\frac{-(K+12)}{3} > 0 \Rightarrow K < -12$$

$$2K-4 > 0 \Rightarrow K > 2 \quad\text{and}\quad K > -33,$$

These condition can not be met simultaneously. System is unstable for any value of K.

MCQ 1.38 Consider the following system

a. $T(s) = \frac{5}{(s+3)(s+6)}$

b. $T(s) = \frac{10(s+7)}{(s+10)(s+20)}$

c. $T(s) = \frac{20}{s^2+6s+44}$

d. $T(s) = \frac{s+2}{s^2+9}$

e. $T(s) = \frac{(s+5)}{(s+10)^2}$

Consider the following response

1. Over damped
2. Under damped
3. Under damped
4. Critically damped

The correct match is

	1	2	3	4
(A)	a	c	d	e
(B)	b	a	d	e
(C)	c	a	e	d
(D)	c	b	e	d

SOL 1.38 Option (A) is correct.

1. Over damped response (a, b)

Poles : Two real and different on negative real axis.

2. Under damped response (c)

Poles : Two complex in left half plane

Poles : Two complex in left half plane

3. Undamped response (d)

Poles : Two imaginary

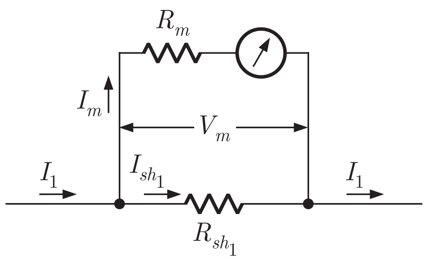
4. Critically damped (e)

Poles : Two real and same on negative real axis.

MCQ 1.39 A PMMC instrument has full-scale deflection current of 100 μA and a coil resistance of 1 kΩ. The value of required shunt resistance to convert the instrument into an ammeter with a full scale deflection current of 100 mA is R_{sh_1}. The same instrument is converted into an ammeter with a full scale deflection current of 1 mA by using a shunt resistor R_{sh_2}. The ratio $\frac{R_{sh_1}}{R_{sh_2}}$ approximately equals to

(A) 10
(B) 100
(C) 0.1
(D) 1

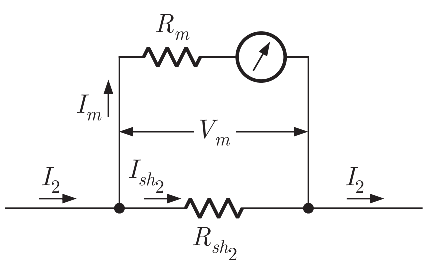
SOL 1.39 Option (A) is correct.



For full scale deflection current 100 mA

$$I_{fsd_1} = 100\text{ mA}$$
$$V_m = I_m R_m = 100\,\mu\text{A} \times 1\,\text{k}\Omega = 100\text{ mV}$$
$$I_1 = I_{sh_1} + I_m$$
$$I_{sh_1} = I_1 - I_m \qquad \therefore I_1 = I_{fsd_1} = 100\text{ mA}$$
$$= 100\text{ mA} - 100\,\mu\text{A} = 99.9\text{ mA}$$
$$R_s = \frac{V_{m_1}}{I_{sh_1}} = \frac{100\text{ mV}}{99.9\text{ mA}} = 1.001\,\Omega$$

Now for full scale deflection current of 1 A



$$I_{fsd_2} = 1\text{ A}$$
$$V_m = I_m R_m = 100\text{ mV}$$
$$I_{sh_2} = I_2 - I_m \qquad \therefore I_2 = I_{fsd_2} = 1\text{ A}$$
$$= 1\text{ A} - 100\,\mu\text{A} = 999.9\text{ mA}$$
$$R_s = \frac{V_m}{I_{sh_2}} = \frac{100\text{ mV}}{999.9\text{ mA}} = 0.10001\,\Omega$$

Ratio $$\frac{R_{sh_1}}{R_{sh_2}} = \frac{1.001}{0.10001} = 10$$

MCQ 1.40 A 50 Hz, bar primary CT has a secondary with 300 turns. The secondary supplies 5 A current into a burden which consists of a resistance and reactance of $1.5\,\Omega$ and $1.0\,\Omega$ respectively. The magnetizing mmf is 100 A and the iron loss is 1.2 W. The phase angle between the primary and secondary is

(A) 11.7° (B) 2.34°

(C) 4.025° (D) 0.847°

SOL 1.40 Option (B) is correct.

Secondary circuit phase angle

$$\delta = \tan^{-1}\left(\frac{1}{1.5}\right) = 33.69°$$

$$\cos\delta = \cos 33.69^\circ = 0.832, \text{ and}$$

or,
$$\sin\delta = \sin 33.69^\circ = 0.555$$

Turn ratio
$$K_t = \frac{N_s}{N_p} = \frac{300}{1} = 300$$

Magnetizing current

$$I_m = \frac{\text{Magnetising } mmf}{N_p} = \frac{100}{1} = 90 \text{ A}$$

Secondary circuit burden impedance $= \sqrt{(1.5)^2 + (1.0)^2} = 1.8\,\Omega$

Secondary induced voltage

$$E_s = 5 \times 1.8 = 9 \text{ V}$$

Primary induced voltage

$$E_p = \frac{E_s}{300} = \frac{9}{300}$$

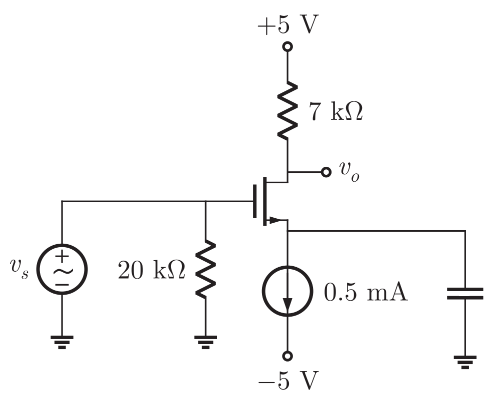
Loss component
$$I_w = \frac{\text{iron loss}}{E_p} = \frac{1.2}{(9/300)} = 40 \text{ A}$$

Phase angle
$$\theta = \frac{180}{\pi}\left(\frac{I_m\cos\delta - I_w\sin\delta}{K_t I_s}\right)$$

$$= \frac{180}{\pi}\left(\frac{100 \times 0.832 - 40 \times 0.555}{300 \times 5}\right)$$

$$= 2.34^\circ$$

MCQ 1.41 Consider the common-source circuit with source bypass capacitor. The signal frequency is sufficiently large. The transistor parameters are $V_{TN} = 0.8$ V, $K_n = 1$ mA/V^2 and $\lambda = 0$. The voltage gain is



(A) -15.6 (B) -9.9

(C) -6.8 (D) -3.2

SOL 1.41 Option (B) is correct.

Since the DC gate current is zero, $v_s = -V_{GSQ}$

$$I_{DQ} = I_Q = K_n(V_{GSQ} - V_{TN})^2$$

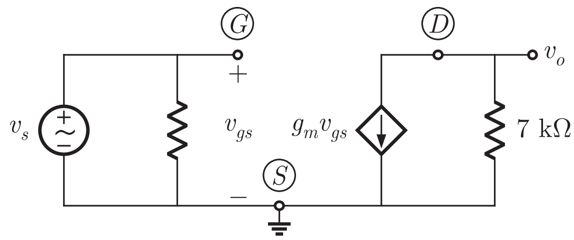
$\Rightarrow$
$$0.5 = 1(V_{GSQ} - 0.8)^2$$

$$V_{GSQ} = 1.51 \text{ V} = -v_s$$

$$V_{DSQ} = 5 - (0.5\text{m})(7\text{k}) - (-1.51) = 3.01 \text{ V}$$

The transistor is therefore biased in the saturation region.

The small-signal equivalent circuit is shown below



$$v_o = -g_m v_{gs}(7\text{k})$$

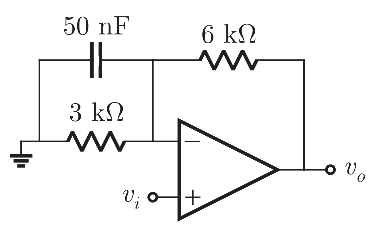
$$v_{gs} = v_i, \frac{v_o}{v_i} = A_v = -g_m(7\text{k})$$

$$g_m = 2K_n(V_{GS} - V_{TN})$$

$$= 2(1\text{m})(1.51 - 0.8) = 1.42 \text{ mS}$$

$$A_v = -(1.42\text{m})(7\text{k}) = -9.9$$

MCQ 1.42 In the following circuit the 3 dB cutoff frequency is



(A) 10 kHz (B) 1.59 kHz

(C) 354 kHz (D) 689 Hz

SOL 1.42 Option (B) is correct.

Let $R_1 = 3\,\text{k}\Omega,\ R_2 = 6\,\text{k}\Omega,\ C = 50\,\text{nF}$

$$\frac{v_i}{R_1 \| \left(\frac{1}{sC}\right)} + \frac{v_i - v_o}{R_2} = 0$$

$$\Rightarrow \quad \frac{v_i}{\left(\frac{R_1}{1 + sR_1C}\right)} + \frac{v_i}{R_2} = v_o$$

$$v_i\left[\frac{R_2}{R_1}(1 + sR_1C) + 1\right] = v_o$$

$$\frac{v_i}{R_1}[R_2 + R_1 + sR_1R_2C] = v_o$$

$$\frac{v_o}{v_i} = \frac{R_2 + R_1}{R_1}\left[1 + \frac{sR_1R_2C}{R_1 + R_2}\right]$$

$$\Rightarrow \quad \frac{v_o}{v_i} = \left(1 + \frac{R_2}{R_1}\right)(1 + s(R_1 \| R_2)C)$$

$$f_{3dB} = \frac{1}{2\pi(R_1 \| R_2)C}$$

$$= \frac{1}{2\pi(3k \| 6k)50n} = \frac{1}{2\pi(2k)50n} = 1.59 \text{ kHz}$$

MCQ 1.43 An $X-Y$ flip-flop whose characteristic table is given below is to be implemented using a J-K flip-flop

This can be done by using

(A) $J = X, K = \overline{Y}$

(B) $J = \overline{X}, K = Y$

(C) $J = Y, K = \overline{X}$

(D) $J = \overline{Y}, K = X$

SOL 1.43 Option (D) is correct.

Let Q_n is the present state and Q_{n+1} is next state of given $X-Y$ flip-flop.

X	Y	Q_n	Q_{n+1}
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	0	0

Solving from K-map we get

Characteristic equation of $X-Y$ flip-flop is

$$Q_{n+1} = \overline{Y}\,\overline{Q}_n + \overline{X}Q_n$$

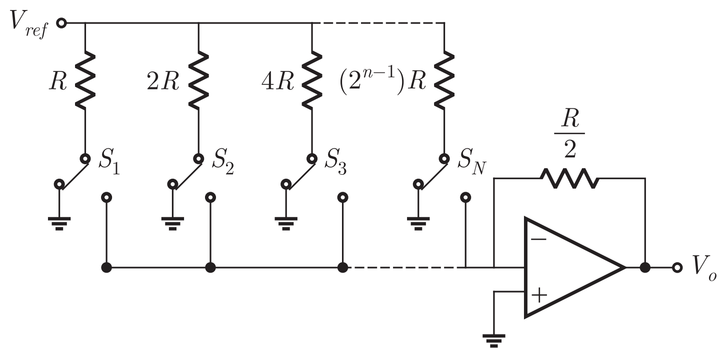
Characteristic equation of a $J-K$ flip-flop is given by

$$Q_{n+1} = J\overline{Q}_n + \overline{K}Q_n$$

By comparing

$J = \overline{Y}$, $K = X$

MCQ 1.44 Consider a binary weighted n-bit D/A converter shown in the following circuit of figure. What is the tolerance of resistance to limit the output error to the equivalent of $\pm\frac{1}{2}$ LSB ?



(A) $\frac{1}{2^n - 1}$ (B) $\frac{1}{2^n}$

(C) $\frac{1}{2^{n-1}}$ (D) $\frac{1}{2^n + 1}$

SOL 1.44 Option (A) is correct.

Required error in MSB $\leq 1/2$ LSB

Let $\pm x\,\%$ is the tolerance in resistance

$$\frac{V}{R} - \frac{V}{R\left(1+\frac{x}{100}\right)} \leq \frac{1}{2}\frac{V}{2^{n-1}R}$$

$$\frac{\left(1+\frac{x}{100}\right)-1}{\left(1+\frac{x}{100}\right)} \leq \frac{1}{2^n}$$

$$\frac{x}{100} \times 2^n \leq 1 + \frac{x}{100}, \quad \frac{x}{100}(2^n - 1) \leq 1$$

$$x \leq \frac{1}{2^n - 1} \times 100$$

MCQ 1.45 Consider the following 8085 program

```
         MVI    A, DATA 1
         ORA    A,
         JM     DSPLY
         OUT    PORT1
         CMA
DSPLY :  ADI    01H
         OUT    PORT1
         HLT
```

If DATA1 = A7H, the output at PORT1 is

(A) 47H (B) 58H

(C) 00 (D) None of the above

SOL 1.45 Option (C) is correct.

```
MVI  A, DATA1    ; DATA1 → A
ORA  A           ; Set flag
```

```
         JM    DSPLY     ; If negative jump to DSPLY
         OUT   PORT1     ; A → PORT1
DSPLY :  CMA             ; Complament A
         ADI   01H       ; A + 1 → A
         OUT   PORT1     ; A → PORT1
         HLT
```

This program displays the absolute value of DATA1. If DATA is negative, it determine the 2's complements and display at PORT1.

MCQ 1.46 The system equations $x+y+z=6$, $x+2y+3z=10$, $x+2y+\lambda z=12$ is inconsistent, if λ is

(A) 3　　(B) -3

(C) 0　　(D) None of these

SOL 1.46 Option (A) is correct.

Equation $\mathbf{A}x=\mathbf{B}$ is consistent only if $\rho(\mathbf{A})=\rho(\mathbf{A}:\mathbf{B})$

Otherwise system is said to be inconsistent i.e. possesses no solution. Now,

$$[\mathbf{A}:\mathbf{B}]=\begin{bmatrix}1&1&1&:&6\\1&2&3&:&10\\1&2&\lambda&:&12\end{bmatrix}$$

$$=\begin{bmatrix}1&1&1&6\\1&1&2&4\\1&2&\lambda-1&2\end{bmatrix}\qquad\begin{pmatrix}R_2-R_1\Rightarrow R_2\\R_3-R_1\Rightarrow R_3\end{pmatrix}$$

$$=\begin{bmatrix}1&1&1&6\\0&1&2&4\\0&0&\lambda-3&2\end{bmatrix}\qquad(R_3-R_2\Rightarrow R_3)$$

$\Rightarrow$ $$\rho(\mathbf{A}:\mathbf{B})=3$$

As one of the minor $\begin{vmatrix}1&1&6\\0&1&4\\0&0&2\end{vmatrix}\neq 0$

Now, system is inconsistent if

$$\rho(\mathbf{A})\neq\rho(\mathbf{A}:\mathbf{B})\text{ i.e. }\rho(\mathbf{A})\neq 3$$

It is possible only when $\lambda-3=0$ i.e. $\lambda=3$

MCQ 1.47 For the differential equation $\frac{dy}{dx}=x-y^2$ given that

x:	0	0.2	0.4	0.6
y:	0	0.02	0.0795	0.1762

Using Milne predictor-correction method, the y at next value of x is

(A) 0.2498　　(B) 0.3046

(C) 0.4648　　(D) 0.5114

SOL 1.47 Option (B) is correct.

x: 0 0.2 0.4 0.6

On calculation we get

$$f(x) = x - y^2$$
$$f_1(x) = 0.1996$$
$$f_2(x) = 0.3937$$
$$f_3(x) = 0.5689$$

Using predictor formula

$$y_4^{(p)} = y_0 + \frac{4}{3}h(2f_1 - f_2 + 2f_3)$$

Here $h = 0.2$

$$y_4^{(p)} = 0 + \frac{0.8}{3}[2(.1996) - (.3937) + 2(.5689)]$$

$$y_4^{(c)} = y_2 + \frac{h}{3}(f_2 - 4f_3 + f^*_3),$$

$$f^*_4 = f(x_4, y_4^{(p)}) = f(.8, 0.3049) = .07070$$

$$y_4^{(c)} = .0795 + \frac{2}{30}[.3937 + 4(.5689) + .7070] = .3046$$

Statement for Question 48-49 :

A single phase half-bridge inverter is operated from a 24 V source and supplies power to a resistive load.

MCQ 1.48 Total harmonic distortion(THD) is

(A) 48.4% (B) 19.8%

(C) 60% (D) 28%

SOL 1.48 Option (A) is correct.

RMS value of fundamental component is

$$V_{1\text{rms}} = \frac{2V_{dc}}{\sqrt{2}\,\pi} = 10.8 \text{ V} \qquad V_{dc} = 24 \text{ V}$$

$$\text{RMS harmonic voltage} = \left[\sum_{n=3,5,7}^{\infty} V_{n_{\text{rms}}}^2\right]^{1/2}$$

$$= \sqrt{V_0^2 - V_{1\text{rms}}^2} = [12^2 - (10.8)^2]^{1/2}$$

$$= 5.23 \text{ V}$$

Total harmonic distortion (THD)

$$THD = \frac{1}{V_{1\text{rms}}}\left[\sum_{n=2,3}^{\infty} V_{n_{\text{rms}}}^2\right]^{1/2}$$

$$= \frac{\sqrt{V_0^2 - V_{1\text{rms}}^2}}{V_{1\text{rms}}}$$

$$THD = \frac{5.23}{10.8} = 0.484 = 48.4\%$$

MCQ 1.49 The harmonic factor and the distortion factor for the lowest order harmonic are respectively

(A) 20%, 2.22%
(B) 7.68%, 33.33%
(C) 33.33%, 3.7%
(D) 35.88%, 3.98%

SOL 1.49 Option (C) is correct.

We have, RMS value of fundamental component

$$V_{1rms} = \frac{2V_{dc}}{\sqrt{2}\,\pi} = 10.8 \text{ V}$$

The lowest harmonic is third harmonic. Third harmonic voltage is

$$V_{3rms} = \frac{2V_{dc}}{3\pi\sqrt{2}} = 3.6 \text{ V} \qquad V_{dc} = 24 \text{ V}$$

HF for the third harmonic

$$HF_3 = \frac{V_{3rms}}{V_{1rms}} = \frac{3.6}{10.8} = 33.33\%$$

DF of the third harmonic

$$DF_3 = \frac{(V_{3rms}/3^2)}{V_{1rms}} = \frac{3.6/9}{10.8} = 0.037 = 3.7\%$$

Statement for Q. 50-51

A power plant consisting of two generations G_1 and G_2 supplies a total load of 450 MW. The fuel costs of two generations G_1 and G_2 are C_1 and C_2 respectively, given as following

$$C_1 = 100 + 2P_1 + 0.005P_1^2$$
$$C_2 = 200 + 2P_2 + 0.01P_2^2$$

where P_1 and P_2 are the generation in MW of G_1 and G_2 respectively.

MCQ 1.50 The economic load scheduling of the two units will be

(A) $P_1 = 225$ MW, $P_2 = 225$ MW
(B) $P_1 = 180$ MW, $P_2 = 270$ MW
(C) $P_1 = 300$ MW, $P_2 = 150$ MW
(D) $P_1 = 240$ MW, $P_2 = 210$ MW

SOL 1.50 Option (C) is correct.

The incremental fuel cost of G_1

$$\frac{dC_1}{dP_1} = 2 + 0.01P_1$$

The incremental fuel cost of G_2

$$\frac{dC_2}{dP_1} = 2 + 0.02P_2$$

For optimum load division the two incremental costs should be equal, that is

$$\frac{dC_1}{dP_1} = \frac{dC_2}{dP_1}$$

$$2 + 0.01P_1 = 2 + 0.02P_2$$

$$P_1 = 2P_2 \qquad ...(i)$$

Total load by the two generators

$$P_1 + P_2 = 450 \qquad ...(ii)$$

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

$$P_1 = 300\,\text{MW}, P_2 = 150\,\text{MW}$$

MCQ 1.51 The incremental fuel cost of the power plant in Rs/MWh will be

(A) 4.25 Rs/MWh (B) 10 Rs/MWh

(C) 5 Rs/MWh (D) 6.5 Rs/MWh

SOL 1.51 Option (C) is correct.

The incremental fuel cost of G_1

$$\frac{dC_1}{dP_1} = 2 + 0.01P_1$$
$$= 2 + 0.01 \times 300 = 5\,\text{Rs/MWh}$$

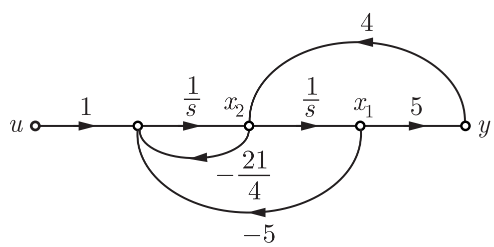
The incremental fuel cost of G_2

$$\frac{dC_2}{dP_1} = 2 + 0.02P_2$$
$$= 2 + 0.02 \times 150 = 5\,\text{Rs/MWh}$$

Hence the incremental fuel cost of the plant for most economic operation is 5 Rs/MWh.

Statement for Q. 52-53 :

A state flow graph is shown below



MCQ 1.52 The state and output equation for this system is

(A) $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & -1 \\ 5 & \frac{21}{4} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u,\ y = \begin{bmatrix} 5 & 4 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

(B) $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -5 & -\frac{21}{4} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u,\ y = \begin{bmatrix} 5 & 4 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

(C) $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -5 & -\frac{21}{4} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix}u,\ y = \begin{bmatrix} 4 & 5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

(D) $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -5 & -\frac{21}{4} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix}u,\ y = \begin{bmatrix} 4 & 5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

SOL 1.52 Option (B) is correct.

$$\dot{x}_2 = -5s_2 - \frac{21}{4}x_2 + u,$$

$$\dot{x}_1 = x_2,$$
$$y = 5x_1 + 4x_2$$
$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -5 & -\frac{21}{4}\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u,\ y = \begin{bmatrix}5 & 4\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

MCQ 1.53 The system is

(A) Observable and controllable (B) Controllable only

(C) Observable only (D) None of the above

SOL 1.53 Option (B) is correct.

$$O_M = \begin{bmatrix}C\\ CA\end{bmatrix} = \begin{bmatrix}5 & 4\\ -20 & 1\end{bmatrix}$$

det $O_M = 0$. Thus system is not observable

$$C_M = \begin{bmatrix}B & AB\end{bmatrix} = \begin{bmatrix}0 & 1\\ 1 & -\frac{21}{4}\end{bmatrix}$$

det $C_M = -1$. Thus system is controllable.

Statement for Q. 54-55:

Two generators G_1 and G_2 are to be operated in parallel to deliver a total current of 60 A. Generator G_1 has a terminal voltage of 280 V on no-load and 240 V when supplying 40 A current. Similarly the second generator has a voltage of 300 V when on no-load and 240 V when supplying 50 A of current.

MCQ 1.54 The output voltage of each generator will be

(A) 240 V (B) 238.2 V

(C) 271.7 V (D) 256.4 V

SOL 1.54 Option (D) is correct.

Generator G_1:

$$\text{Voltage drop per ampere} = \frac{280 - 240}{40} = 1\text{ A}$$

Let output current is I_{G_1}, then output voltage will be

$$V_{G_1} = 280 - 1 \times I_{G_1}$$

Generator G_2:

$$\text{Voltage drop per ampere} = \frac{300 - 240}{50} = 1.2\text{ A}$$

Let output current is I_{G_2}, then output voltage will be

$$V_{G_2} = 300 - 1.2 \times I_{G_2}$$

For parallel operation, output of each generator would be same i.e.

$$V_{G_1} = V_{G_2}$$

$$280 - 1 \times I_{G_1} = 300 - 1.2 \times I_{G_2}$$

or
$$-I_{G_1} + 1.2 I_{G_2} = 20 \quad \text{...(i)}$$

Total current delivered

$$I_{G_1} + I_{G_2} = 60 \quad \text{...(ii)}$$

Solving equation (i) and (ii) we get

$$I_{G_1} = 23.6 \text{ A and } I_{G_2} = 36.4 \text{ A}$$

So the output voltage

$$V_{G_1} = V_{G_2} = 256.4 \text{ V}$$

MCQ 1.55 The output power P_{G_1} and P_{G_2} delivered by generator G_1 and G_2 will be

(A) $P_{G_1} = 5.6\text{ kW}, P_{G_2} = 8.7\text{ kW}$
(B) $P_{G_1} = 9.6\text{ kW}, P_{G_2} = 12\text{ kW}$
(C) $P_{G_1} = P_{G_2} = 9.3\text{ kW}$
(D) $P_{G_1} = 6\text{ kW}, P_{G_2} = 9.3\text{ kW}$

SOL 1.55 Option (D) is correct.

$$P_{G_1} = V_{G_1} I_{G_1} = 256.4 \times 23.6 = 6.05\text{ kW}$$
$$P_{G_2} = V_{G_2} I_{G_2} = 256.4 \times 36.4 = 9.3\text{ kW}$$

Q.56 TO Q.60 CARRY ONE MARK EACH

MCQ 1.56 Which one of the following is the Antonym of the word FEARLESS ?

(A) intrepid
(B) craven
(C) vacillate
(D) oscillate

SOL 1.56 Correct option is (B)

MCQ 1.57 Which one of the following is the synonym of the word CONTROVERSIAL ?

(A) pulse
(B) polemic
(C) record
(D) integrity

SOL 1.57 Correct option is (B)

MCQ 1.58 One of the four words given in the four options does not fit the set of words. The odd word from the group, is

(A) Break
(B) Hiatus
(C) Pause
(D) End

SOL 1.58 Correct option is (D)

MCQ 1.59 A pair of CAPITALIZED words shown below has four pairs of words. The pair of words which best expresses the relationship similar to that expressed in the capitalized pair, is

ENTHUSIASTIC : FANATICAL

(A) Frugal : Miserly
(B) Faithful : Kind
(C) Admonish : Warn
(D) Virtuous : Wholesome

SOL 1.59 Correct option is (A)

MCQ 1.60 In the following sentence, a part of the sentence is left unfinished. Four different ways of completing the sentence are indicated. The best alternative among the four, is

No doubt, it was our own government but it was being run on borrowed ideas, using...............solutions.

(A) worn out (B) second hand

(C) impractical (D) appropriate

SOL 1.60 Correct option is (B)

Q.61 TO Q.65 CARRY TWO MARK EACH

MCQ 1.61 After striking the floor, a Tennis ball rebounds to 4/5th of the height from which it has fallen. What will be the total distance that it travels before coming to rest if it has been gently dropped from a height of 90 meters. ?

(A) 675 metres (B) 810 metres

(C) 920 metres (D) 1020 metres

SOL 1.61 Correct option is (B).

The first drop is 90 metres. After thus the ball will rise by 72 metres and fall by 72 metres, now this process will be continue in the form of an infinite GP with common ratio 0.8 and first term 72.

The required answer will be got by

$$= 90 + 2\left(\frac{72}{1-0.8}\right)$$

MCQ 1.62 The ratio of cost price and marked price of a cell phone is $2:3$ and ratio of profit percentage and discount percentage is $3:2$.What is the discount percentage ?

(A) 8% (B) 12%

(C) 16.66% (D) 19.5%

SOL 1.62 Correct option is (C).

$$\text{CP : MP} = 2x:3x$$

$$\Rightarrow \quad \text{Profit} = x$$

$$(\%)\ \text{profit} : (\%)\ \text{discount} = 3:2$$

$$\text{Let} \quad \text{CP} = 200, \text{SP} = 300$$

$$\text{But} \quad \frac{3x}{100}\times 200 + \frac{2x}{100}\times 300 = 100$$

$$\Rightarrow \quad x = 8.33\%$$

$$\text{Discount} = 2x = 16.66\%$$

MCQ 1.63 If prices are reduced 20% and sales increase 15%, what is the net effect on gross receipts ?

(A) They increase by 8%
(B) They decrease by 8%
(C) They remain the same
(D) They increase by 10%

SOL 1.63 Correct option is (B).

Let original price $= p$, and original sales $= s$. Therefore, original gross receipts $= ps$. Let new price $= 0.80p$, and new sales $= 1.15s$. Therefore, new gross receipts $= 0.92ps$. Gross receipts are only 92% of what they were.

MCQ 1.64 Reduction of 20% in the price of sugar enables a housewife to purchase 5 kg more for Rs. 250. What is the original price per kg of sugar ?

(A) Rs. 10 per kg
(B) Rs. 12.5 per kg
(C) Rs. 15 per kg
(D) Rs. 21 per kg

SOL 1.64 Correct option is (B).

Reduction in price — increase in amount

$20\%\left(\frac{1}{5}\right)\downarrow$ — $\frac{1}{4}\uparrow(25\%) = 5\text{ kg}$

It means original amount of sugar needed $= 5 \times 4 = 20$ kg

$$\text{Original price of sugar} = \frac{250}{20} = \text{Rs. } 12.5 \text{ per kg.}$$

MCQ 1.65 A milkman purchases the milk at Rs. x per litre and sells it at Rs. $2x$ per litre still he mixes 1 litres water with every 5 litres of pure milk. What is the profit percentage ?

(A) 115%
(B) 127.5%
(C) 132%
(D) 140%

SOL 1.65 Correct option is (D).

Let the cost price of 1 litre pure milk be Re. 1, then

$$\left.\begin{matrix} 5 \text{ litres (milk)} \rightarrow \text{CP} = \text{Rs. } 5 \\ 1 \text{ litres (water)} \rightarrow \text{CP} = \text{Rs. } 0 \end{matrix}\right\} \rightarrow \text{CP} = \text{Rs. } 5 \text{ only}$$

and 6 litre mixture $\rightarrow$ SP $\rightarrow 6 \times 2 = \text{Rs. } 12$

$$\text{Profit} = \frac{12 - 5}{5} \times 100 = \frac{700}{5} = 140\%$$

ANSWER KEY

1.	2.	3.	4.	5,	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
D	A	D	D	A	D	C	C	C	B	A	A	D	D	A
16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
A	B	C	B	A	B	B	C	A	A	B	C	B	B	D
31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.
A	B	B	A	B	A	D	A	A	B	B	B	D	A	C
46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
A	B	A	C	C	C	B	B	D	D	B	B	D	A	B
61.	62.	63.	64.	65.				.					.	
B	C	B	B	D										