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GATE 2022

ELECTRICAL ENGINEERING

Exam held on **05/02/2022**

Memory based

Questions & Solutions

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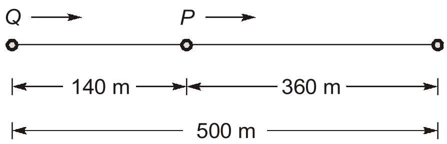
SECTION - A GENERAL APTITUDE

Q.1 A 500 m race the ratio of speed of P and Q is 3 : 4. When the race start P is 140 m ahead. What is the distance between P and Q when P win the race.

(a) 40 m (b) 20 m
(c) 60 m (d) 80 m

Ans. (b)



Ratio of speed = 3 : 4

So, $P : Q = 3\,x : 4\,x$

So, $3x \times t = 360$

$xt = 120$

So distance convered by Q

$= 4x\,t$

$= 4 \times 120 = 480$ m

So, distance differnce = 500 – 480 = 20 m

End of Solution

Q.2 The price of an item is 10% cheaper in online store S compared to the price of another online store M. Store S charges ₹150 for delivery charge. There is no delivery charge for orders from the store M. A person bought the item from store S and saved ₹100. What is the price of the item at the online store M (in ₹) if there are no other charges than what is the described above?

(a) 1750 (b) 2500
(c) 2250 (d) 1500

Ans. (c)

Let price of item at store M is x

So price of item of store is 0.9 x

So, $x - (0.9x + 150) = 100$

$0.1\,x = 2500$

$x = 2500$

So price of item at store S = 0.9×2500

$= 2250$

End of Solution

Q.3 If Ring

Bell (1), Bell (2) and Bell (3) ring after every 20 min, 30 min and 50 min respectively. If they ring at 12 : 00 pm together at time will they ring again

(a) 5 : 00 pm (b) 4 : 00 pm
(c) 6 : 00 pm (d) 4 : 30 pm

Ans. (a)

$$\text{LCM} = (20, 30, 50)$$
$$\text{LCM} = 300 \text{ mim}$$

So, $$\text{LCM} = \frac{300}{60} = 5 \text{ hrs}$$

So, $12{:}00 + 5 \text{ hrs} = 5 : 00 \text{ PM}$

End of Solution

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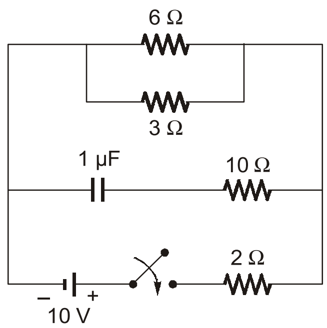
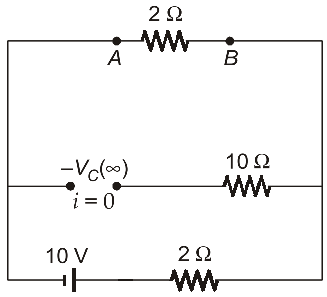
SECTION - B TECHNICAL

Q.1 $t = 0$ which closed magnitude of steady state voltage, (in volts), find voltage across 6 Ω resistor.



Ans. (5)

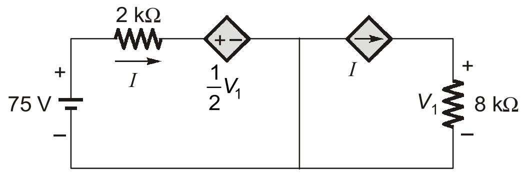
At steady state, capacitor will behave as open circuit,



So, $$V_C(\infty) = \frac{2}{2+2} \times 10 = 5 \text{ V}$$

End of Solution

Q.2



V_1 = _______ V.

Ans. (100)

Here, $$V_1 = 8I$$

and $$-75 + 2I + \frac{1}{2}V_1 = 0$$

$$75 = 2I + \frac{8}{2}I$$

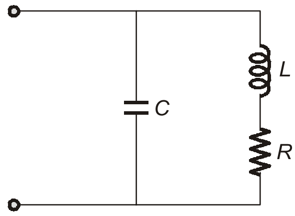
$$I = \frac{75}{2+4} = 12.5 \text{ A}$$

$$V = 8I$$

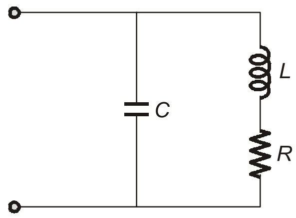
$$V = 8 \times 12.5 = 100 \text{ V}$$

End of Solution

Q.3 The network shown below has a resonant frequency, f = 150 kHz and a bandwidth of 600 Hz. The Q-factor of the network



Ans. (250)

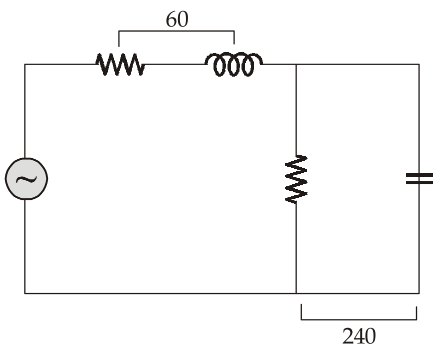


$$Q = \frac{f_r}{f_2 - f_1} = \frac{150 \times 10^3}{600} = 250$$

End of Solution

Q.4 An inductor having Q-factor of 60 is connected in series with a capacitor having a Q-factor of 240. The overall Q-factor of circuit is ______.

Ans. (48)



$$Q = \frac{Q_L \times Q_C}{Q_L \times Q_C} = \frac{60 \times 240}{240 + 60} = 48$$

End of Solution

Q.5 Let an input $x(t) = 2\sin(10\pi t) + 5\cos(15\pi t) + 7\sin(42\pi t) + 4\cos(45\pi t)$ is passed through an LTI system having impulse response.

$$h(t) = 2\left(\frac{\sin(10\pi t)}{\pi t}\right)\cos 40\pi t$$

The output of the system is

(a) $7\sin 42\pi t + 4\cos 45\pi t$
(b) $2\sin 10\pi t + 5\cos 15\pi t$
(c) $2\sin 42\pi t + 4\cos 45\pi t$
(d) $5\sin 15\pi t + 7\cos 42\pi t$

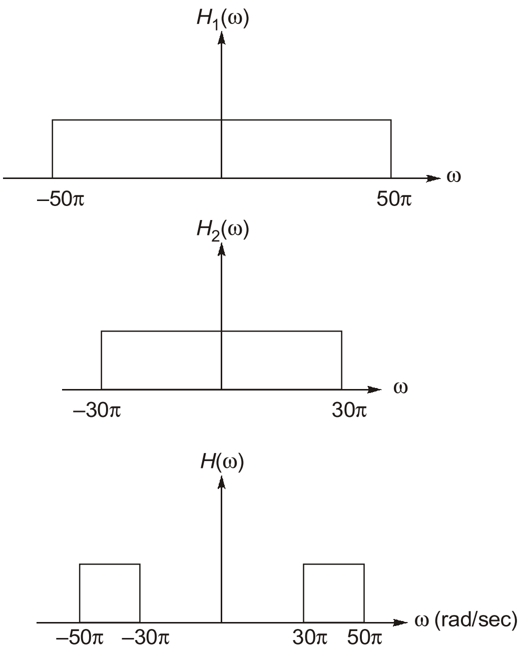
Ans. **(a)**

$$h(t) = \frac{\sin 50\pi t - \sin 30\pi t}{\pi t}$$

$$= \frac{\sin 50\pi t}{\pi t} - \frac{\sin 30\pi t}{\pi t}$$

$$= h_1(t) - h_2(t)$$

By Fourier transform, $H(\omega) = H_1(\omega) - H_2(\omega)$



So the given system is a band pass filter with cut off frequency $\omega_L = 30\pi$ rad/sec and $\omega_H = 50\pi$ rad/sec

$\therefore$ System output: $y(t) = 7\sin 42\pi t + 4\cos 45\pi t$

End of Solution

Q.6 $x(t) \longrightarrow \boxed{y(t) = x(e^{t})} \longrightarrow y(t)$

where $y(t) = x(e^t)$. Then system is

(a) Linear and causal
(b) Non-linear and causal
(c) Non-linear and non causal
(d) Linear and non-causal

Ans. (d)

Part-1

The given system will satisfy law of superposition. So the system will be linear.

Part-2

$$y(t) = x(e^t)$$

Put, $t = 0$,

$$y(0) = x(1)$$

Since output is depending on future value of input. So the system is non-causal.

End of Solution

Q.7 The DTFS of a periodic signal $x(n)$ is given as

$$x(n) = \sum_{k=0}^{N-1} a_k e^{j\frac{2\pi}{N}kn}$$

where $N = 3$ and $a_{-3} = 1$, $a_2 = 1$, $a_4 = 1$

The $x(n)$ can be written as

(a)
(b)
(c) $1 + 2\cos\dfrac{\pi}{3} n e^{-j\pi n}$
(d) $1 + 2\cos\dfrac{\pi}{3} n \cdot e^{j\pi n}$

Ans. (c)

Since, $x(n)$ and a_k have same time-period.

Therefore, $\qquad a_k = a_{k+mN} + a_{k+3m} \qquad \dots$ (i)

where, $\qquad m =$ an – integer

From (i), $\qquad a_{-3} = a_o = 1$

$$a_1 = a_4 = 1$$

$$a_2 = 1$$

Hence,

$$x(n) = \sum_{k=0}^{2} a_k e^{jk\frac{2\pi}{3}n} = a_o + a_1 e^{j\frac{2\pi}{3}n} + a_2 e^{j\frac{4\pi}{3}n}$$

$$= 1 + a_1 e^{j\frac{2\pi}{3}n} + e^{j\frac{4\pi}{3}n}$$

$$x(n) = 1 + e^{j\pi n}\left[a_1 e^{-j\frac{2\pi}{3}n} + e^{j\frac{4\pi}{3}n}\right]$$

$$= 1 + e^{j\pi n}\left[2\cos\frac{\pi}{3}n\right]$$

$$x(n) = 1 + 2\cos\frac{\pi}{3}n \cdot e^{-j\pi n}$$

End of Solution

Q.8 Given system $H(s) = \dfrac{As + B}{s^2 + Cs + D}$,

where A, B, C and D are positive

This system cannot be operated as

(a) LPF (b) HPF

(c) Integrator (d) BPF

Ans. (b)

$$H(s) = \frac{As + B}{s^2 + Cs + D}$$

At low = freq. (s = 0)

$$H(O) = \frac{B}{D}$$

At high – freq. ($s = \infty$)

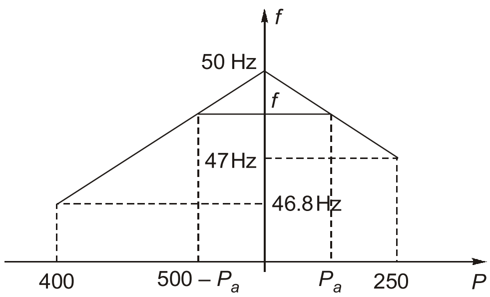
$$H(\infty) = 0$$

Since, $H(\infty)$ should be non-zero for HPF. So, the above system carnot be operated as HPF becasue for high pass filter should pass high-frequency component i.e H(∞) should be non-zero.

End of Solution

Q.9 Two generating units rated for 250 MW and 400 MW have governor speed regulations of 6% and 6.4% respectively from no load to full load. Both operating in parallel and share the load 500 MW. Assuming free governor action, load shared (MW) by 250 MW generating.

Ans. (200)



$$\frac{3}{250} = \frac{50 - f}{P_a} \qquad ...(i)$$

$$\frac{3.2}{400} = \frac{50-f}{500-P_a} \quad \text{...(ii)}$$

Equation (i) divide by equation (ii),

$$\frac{3/250}{3.2/400} = \frac{500-P_a}{P_a}$$

$$1.5 = \frac{500-P_a}{P_a}$$

$$P_a = 200 \text{ MW}$$

End of Solution

Q.10 The valid positive, negative and zero sequence impedance (in pu), for 220 kV, fully transposed 3-ϕ transmission line are

(a) 1.1, 0.15 and 0.08
(b) 0.1, 0.3 and 0.1
(c) 0.15, 0.15 and 0.35
(d) 0.2, 0.2 and 0.2

Ans. **(c)**

For 3-ϕ full transferred transmission line,

$$X_1 \cong X_1 < X_0$$

So suitable answer from given options is option (c)

$$X_1 = X_2 = 0.15$$

$$X_0 = 0.35$$

End of Solution

Q.11 A 20 MVA, 11.2 kVA, 4 pole, 50 Hz alternator has an inertia constant of 15 MJ/MVA. If the input and output power of the alternator are 15 MW and 10 MW, the angular acceleration in mech-degree/s^2 is ______ .

Ans. **(75)**

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

$$P_a = 15 - 10 = 5$$

So, $$m\alpha = P_a$$

$$\alpha = \frac{P_a}{m}$$

$$m = \frac{Hs}{180f} = \frac{15\times 20}{180\times 50} = \frac{1}{30}$$

So, $$\alpha = \frac{5}{1/30} = 150 \text{ electrical degree/sec}^2$$

$$\alpha = 150\times\frac{2}{P} \text{ mechanical degree/sec}^2$$

$$\alpha = 75 \text{ mechanical degree}$$

End of Solution

Q.12 If only 5% of the supplied power to a cable receive at the output terminals, the power loss in the cable is _______ dB.

Ans. (–0.22)

$$P_0 = 5\% \text{ of } P_{in}$$
$$P_L = 95\% \text{ of } P_{in}$$

So, $$P_L = 0.95\, P_{in}$$

So, in decibel, $$P_L = 10\log\left(\frac{P_L}{P_{in}}\right) = 10\log(0.95)$$

$$P_L = -0.22$$

End of Solution

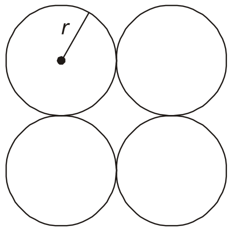
Q.13 The most commonly relay used for protection against loss of excitation is

(a) Buchholz relay
(b) differential relay
(c) offset Mho relay
(d) over current relay

Ans. (c)

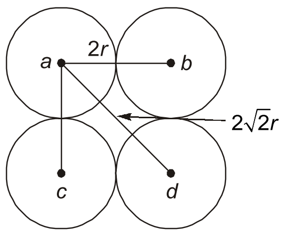
End of Solution

Q.14 The GMR of a conductor, each of radius 'r'



(a) 1.414 r
(b) 4 r
(c) 2 r
(d) 1.723 r

Ans. (d)



$$\text{GMR} = \left[D_{aa}\ \ D_{ab}\ \ D_{ac}\ \ D_{ad}\right]^{1/4}$$

$$= \left[e^{-1/4}r \cdot 2r \cdot 2r \cdot 2\sqrt{2}\, r\right]^{1/4}$$

$$\text{GMR} = 1.723r$$

End of Solution

Q.15 A generating plan has two generating units with cost curve,

$$F_1(P_1) = 0.004P_1^2 + 6P_1 + 350 \text{ Rs./hr}$$

$$F_2(P_2) = 0.003P_2^2 + aP_2 + 450 \text{ Rs./hr}$$

Also $P_1 + P_2 = 550$ MW.

Find P_1 and P_2 for plant incremental cost $\lambda = 8$ Rs/MWhr

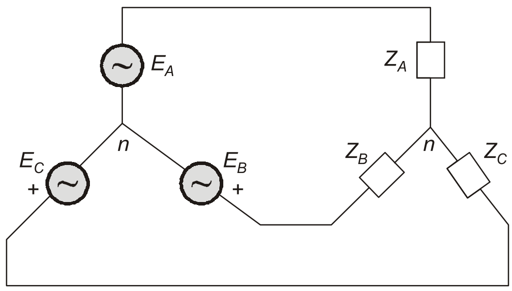
(a) 200 MW, 350 MW
(b) 300 MW, 250 MW
(c) 250 MW, 300 MW
(d) 300 MW, 250 MW

Ans. (c)

$$IC_1(P_1) = 0.008P_1 + 6$$
$$IC_2(P_2) = 0.006P_2 + a$$
$$I_{C1} = I_{C2} = \lambda = 8$$
$$\Rightarrow \quad I_{C1} = 8$$
$$0.008P_1 + 6 = 8$$
$$P_1 = 250 \text{ MW}, \; P_2 = 300 \text{ MW}$$

End of Solution

Q.16 3-ϕ balanced supply of $100\sqrt{3}$ V with *ABC* sequence, the value of Z_C for that node *n* and *n′* are at same potential



$Z_A = 10\ \Omega$, $Z_B = 20\angle 60°$, Z_C = ______ Ω.

(a) $20\angle 60°$
(b) $20\angle -60°$
(c) $20\angle 30°$
(d) $20\angle -30°$

Ans. (b)

n and *n′* are same potential,

So, $I_A + I_B + I_C = 0$

$$\frac{E_A}{Z_A} + \frac{E_B}{Z_B} + \frac{E_C}{Z_C} = 0$$

$$\frac{100\angle 0°}{10} + \frac{100\angle -120°}{20\angle 60°} + \frac{100\angle 120°}{Z_C} = 0$$

$$10 + 5\angle -180° + \frac{100\angle 120°}{Z_C} = 0$$

$$Z_C = 20\angle -60°\ \Omega$$

End of Solution

Q.17 A 1-ϕ full bridge rectifier feeds a resistive load of 50 Ω from 1-ϕ AC supply of 200 V, 50 Hz. Active power drawn by the load is ______ W.

Ans. (800)

1-ϕ full bridge diode rectifier,

Load, $R = 50\ \Omega$

1-ϕ Active power supply

$$V_s = 200 \text{ Volts}$$

$$P_{0\text{ avg}} = \frac{V_{0\text{rms}}^2}{R}$$

$$V_{0r} = V_{s\text{ rms}} = 200 \qquad \text{(for 1-}\phi\text{ full bridge rectifier)}$$

$$P_{0\text{ avg}} = \frac{200^2}{50} = 800 \text{ W}$$

End of Solution

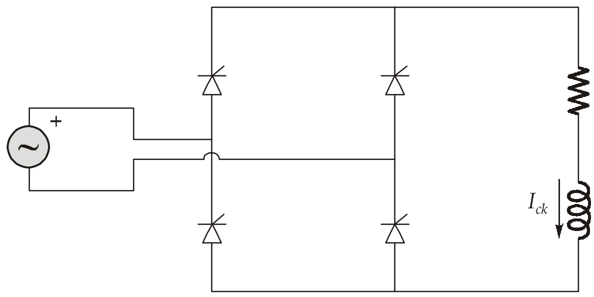
Q.18 A charger supplies 100 W at 20 Volts for charging the battery of the laptop. The power devices used in the converter inside the charger operates at a switching frequency of 200 kHz. Which power device is best suitable for this purpose?

(a) IGBT
(b) MOSFET
(c) BJT
(d) Thyristor

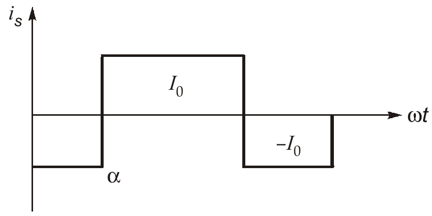
Ans. (b)

End of Solution

Q.19 An ideal AC-DC rectifier circuit, load current is I_{DC} = 15 A and ripple free. If Thyristor are fired with α = 45°, then fundamental amplitude of source current is ______ .



Ans. (19)

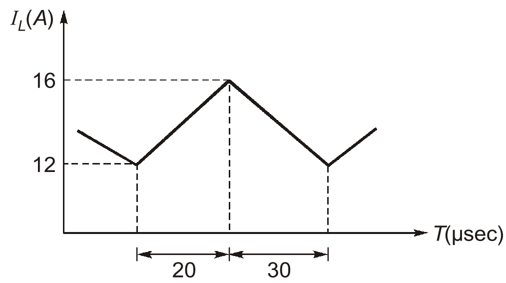


$$\hat{I}_{sn} = \frac{4 \cdot I_0}{n\pi}$$

$$\hat{I}_{s1} = \frac{4I_0}{\pi} = \frac{4}{\pi}\times 15 = 19 \text{ A}$$

End of Solution

Q.20 The steady state current flowing through inductor of a DC-DC buck boost converter is below. If peak to peak ripple in output voltage of converter is 1 V, then value of output capacitor is ________ μF.



Ans. (168)

$$I_L = \frac{I_{max}+I_{min}}{2} = \frac{16+12}{2} = 14 \text{ A}$$

$$I_0 = I_L(1-\alpha)$$

$$I_0 = 14\times\left(\frac{30}{50}\right) = 8.4 \text{ A}$$

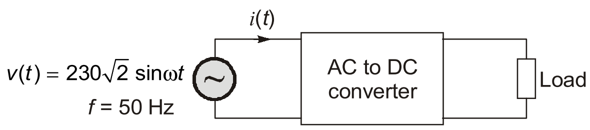
$$\Delta V_0 = \Delta V_c = \frac{\alpha\cdot I_0}{f\cdot C}$$

$$1 = \frac{\left(\frac{2}{5}\right)\times 8.4}{\frac{1}{50.10^{-6}}\cdot C}$$

$$C = 168 \text{ μF}$$

End of Solution

Q.21



$i(t) = 10\sin\left(\omega t-\frac{\pi}{3}\right)+4\sin\left(3\omega t-\frac{\pi}{6}\right)+3\sin\left(5\omega t-\frac{\pi}{3}\right)$A. The power factor at the input side of the converter is ________ .

Ans. (0.447)

$$g = \frac{I_{s1}}{I_{sr}} = \frac{10/\sqrt{2}}{\sqrt{\left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{4}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2}}$$

$$g = 0.89$$

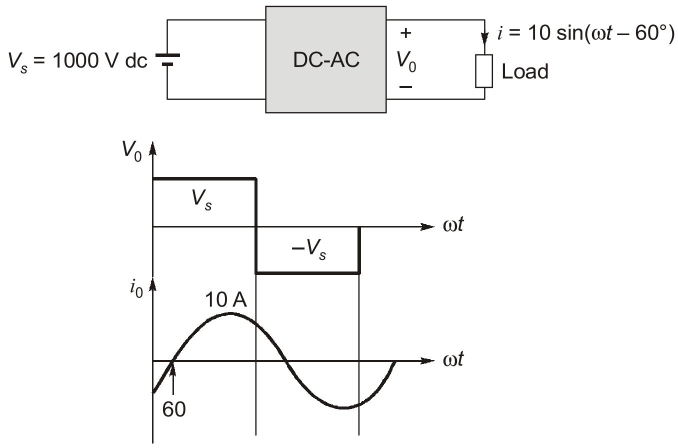
$$pF = g \cdot FDF$$

$$pF = g \cdot \cos\left(\frac{\pi}{3}\right) = 0.447$$

End of Solution

Q.22 A single phase inverter voltage output waveform given with 50% duty cycle. DC voltage given is 10000 V and output current equation is in form 10 sin (ωt – 60). The active power output is _________ .

Ans. (3181.98)



$$P_0 = P_{01}$$

$$= V_{01} \cdot I_{0r} \cdot \cos(60°)$$

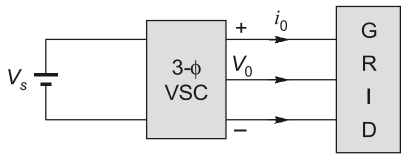
$$= \left(\frac{2\sqrt{2}}{\pi} \cdot (1000)\right) \cdot \left(\frac{10}{\sqrt{2}}\right) \times (0.5)$$

$$= 3181.98 \text{ W}$$

End of Solution

Q.23 A 3-ϕ VSC (DC to AC) is employed using SPWM technique. The dc bus voltage is 1000 Volts. The phase current on AC side of converter is 10 Amp (rms) and complex power at output is (–4000 – j3000) VA, the modulation index is _______ .

Ans. (0.47)



$$S = (-4000 - j3000)\text{ VA}$$

$$P_0 = \sqrt{3} \cdot V_{L1} \cdot I_{0r} \cdot (\text{pF})$$

$$4000 = \sqrt{3} \cdot V_{L1} \cdot 10 \times \left(\frac{4000}{\sqrt{4000^2 + 3000^2}}\right)$$

$$V_{L1\,(\text{rms})} = 288.675\text{ V}$$

3-ϕ VSI – SPWM, $M_A \le 1$

$$\hat{V}_{L1} = \sqrt{3} \cdot M_A \cdot \frac{V_s}{2}$$

$$V_{L1\,(\text{rms})} = M_A\left(\frac{\sqrt{3}}{2\sqrt{2}} \times 1000\right)$$

$$288.675 = M_A\left(\frac{\sqrt{3}}{2\sqrt{2}} \times 1000\right)$$

$$M_A = 0.47$$

End of Solution

Q.24 A 3-ϕ, 415 V, 50 Hz I.M. draws 5 times the rated current at rated voltage at starting. it is required to bring down the starting current from the supply to 2 times of rated current using a 3-ϕ auto-transformation neglect all losses, find transformation ratio of autotransformer ________.

Ans. (0.6324)

Given: $I_{sc} = 5\ I_{\text{rated}} \Rightarrow I_{sc} = 5I_f$

It is required to make starting current to "$2I_f$" using auto transformer.

Line current with auto transformer,

$$I_L = x^2 I_{sc}$$

Given: $I_L = 2I_f \Rightarrow$ $\quad 2I_f = x^2 I_{sc}$

$$\frac{2I_f}{I_{sc}} = x^2$$

$\Rightarrow$ $$x^2 = 2\times\left(\frac{1}{5}\right) \Rightarrow x = \sqrt{\frac{2}{5}} = 0.6324$$

End of Solution

Q.25 A 280 V, separately excited DC motor with Ar. resistance R_a = 1 Ω and constant field excitation drives a load. Load torque (T_L) α speed. Motor draws a current of 30 A running at a speed 1000 rpm. Neglect frictional loss. What will be speed (in rpm) when additional resistance (R_{ext}) = 10 Ω connected in series _____ rpm.

Ans. **(482.76)**

Given: V = 280, Sep. excited motor, R_a = 1 Ω, ϕ : Constant, $T_a \propto I_a$ = 30 A, N = 1000 rpm, R_{ext} = 10 Ω

$$T \propto \phi I_a$$

∴ Flux constant, $T \propto I_a$

$$\frac{T_2}{T_1} = \frac{I_{a2}}{I_{a1}}$$

Given: $T \propto N$

$$\therefore \quad \frac{T_2}{T_1} = \frac{N_2}{N_1}$$

$$\therefore \quad \frac{I_{a2}}{I_{a1}} = \frac{N_2}{N_1}$$

Let, I_{a1} = 30 A, N_1 = 1000 rpm

$$\therefore \quad I_{a2} = \frac{30}{1000}(N_2)$$

$$I_{a2} = 0.03\, N_2$$

$$N \propto \frac{E_f}{\phi}$$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \Rightarrow \frac{N_2}{N_1} = \frac{V - I_{a2}(R_a + R_{ext})}{V - I_{a1}R_a}$$

$$\frac{N_2}{1000} = \frac{280 - 0.03N_2(1+10)}{280 - 30(1)} = \frac{280 - 0.33N_2}{250}$$

$$250N_2 = 280 \times 1000 - 330\, N_2$$

$$N_2 = 482.76 \text{ rpm}$$

End of Solution

Q.26 A star connected 3-ϕ, 400 V 50 kVA, 50 Hz synchronous motor has synchronous reactance = 1 Ω/phase with negligible R_a. The shaft load of motor is 10 kW, while the power factor is 0.8 leading. The loss in motor is 2 kW. The magnitude of excitation voltage per phase is _______ .

Ans. **(244.55)**

Y-connected, 3 phase, 400V, 50 kVA, Synch motor, X_s = 1 Ω/ph, Shaft load P_{sh} = 10 kW, p.f. = 0.8 loading losses = 2 kW, R_a: Negligible

Find excitation EMF (E_b):

$$E_b = \sqrt{(V\cos\phi - I_a R_a)^2 + (V\sin\phi \pm I_a X_s)^2} \qquad (+\text{ for Lead and } - \text{ for lagg})$$

To find I_a: Current drawn, we need to find Input.

$$\text{Input} = \text{Output} + \text{Losses} + P_{sh} + \text{Losses} = 10 + 2 = 12 \text{ kW}$$

$$\sqrt{3}V_L I_L \cos\phi = 12 \text{ kW}$$

$$I_L = \frac{12000}{\sqrt{3}\times 400\times 0.8} = 21.65A = I_a$$

$$E_b = \sqrt{\left(\frac{400}{\sqrt{3}}\times 0.8\right)^2 + \left[\frac{400}{\sqrt{3}}\times 0.6 + 21.65(1)\right]^2}$$

$$E_b = \sqrt{(V\cos\phi - I_a R_a)^2 + (V\sin\phi + I_a X_s)^2}$$

$$= \sqrt{34135.336 + (138.568 + 21.65)^2}$$

$$E_b = 244.55 \text{ V per phase}$$

End of Solution

Q.27 The frequencies of stator rotor currents flowing in 3-ϕ. P = 8, I.M. are 40 Hz and 1 Hz respectively. The motor speed in rpm _______.

Ans. **(585)**

Stator frequency = 40 Hz, Rotor frequency = 1 Hz

Poles = 8, N = ?

$$sf = 1$$

$$\Rightarrow \quad s = \frac{1}{40} = 0.025$$

$$N_s = \frac{120\times 40}{8} = 600$$

$$N = N_s(1 - s)$$

$$\therefore \quad N = 600(1 - 0.025)$$

$$= 585 \text{ rpm}$$

End of Solution

Q.28 The type of 1-ϕ I.M. expected to have the maximum power factor during steady state running condition is _____.

(a) Shaded pole
(b) Split phase (resistance start)
(c) Capacitor start
(d) Capacitor start and capacitor run

Ans. **(d)**

End of Solution

Q.29 Casual LTI system $y(t) + \frac{1}{4}\frac{dy}{dt} = 2\,x(t)$; $x(t)$ and $y(t)$ are input and output respectively.

Its impulse response _______ .

(a) $8e^{-4t}u(t)$ (b) $8e^{-t/4}u(t)$
(c) $2e^{-4t}u(t)$ (d) $2e^{-t/4}u(t)$

Ans. **(c)**

By applying Laplace-transform on given differential equation,

$$Y(s) + \frac{1}{4}s.Y(s) = 2X(s)$$

$$\Rightarrow \quad \frac{Y(s)}{X(s)} = s + \frac{1}{A} = \frac{2}{1+\frac{s}{4}} = \frac{8}{s+4}$$

$$\Rightarrow \quad H(s) = \frac{2}{s+\frac{1}{4}} = \frac{8}{s+4}$$

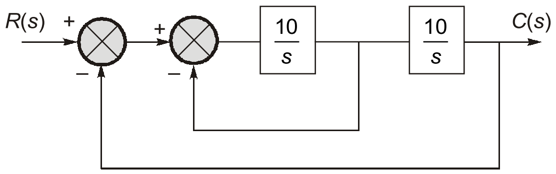
By taking inverse LT,

$$h(t) = 2e^{1/4t} \cdot u(t) = 8e^{-4t}u(t)$$

$$= \text{Impulse response of system.}$$

End of Solution

Q.30 For below given block diagram value of ω_n, ξ will be _______ .



(a) $\xi = 0.707$, $\omega_n = 10$ rad/sec (b) $\xi = 0.707$, $\omega_n = 100$ rad/sec
(c) $\xi = 0.1$, $\omega_n = 10$ rad/sec (d) $\xi = 0.5$, $\omega_n = 10$ rad/sec

Ans. **(d)**

$$\frac{C(s)}{R(s)} = \frac{100}{s^2 + 10s + 100} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$\omega_n = 10 \text{ rad/sec}$$
$$\xi = 0.5$$

End of Solution

Q.31 Open loop system with unit negative feedback $G(s) = \frac{K}{s^2 + 2s - 5}$. For stable system range of K _______ .

(a) $K < 5$
(b) $K > 2$
(c) $K < 2$
(d) $K > 5$

Ans. (d)

Characteristics equation, $1 + G(s) = 0$

$$s^2 + 2s + (K - 5) = 0$$

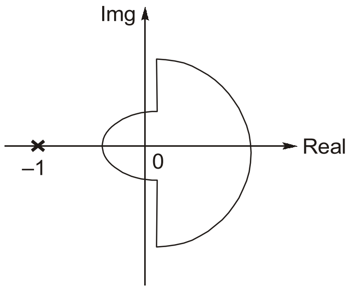
By Routh table analysis,

$$K > 5 \text{ and } k > 0$$

For stable system $k > 5$

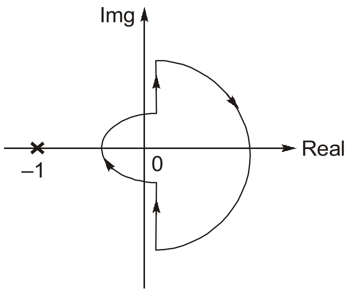
End of Solution

Q.32 Open loop transfer function is given as $G(s) = \frac{K}{s(s+1)}$.



Number of encirclement around point (–1, 0) will be _____

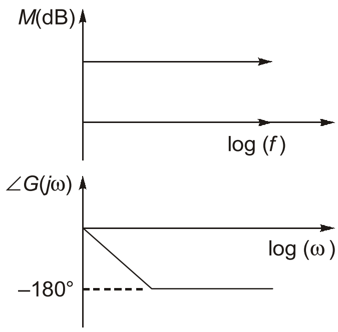
Ans. (1)



Number of Encirclement = 1

End of Solution

Q.33 The Bode plot of first order system is given



The above system has _______ .

Ans. ()

$$P = 1$$

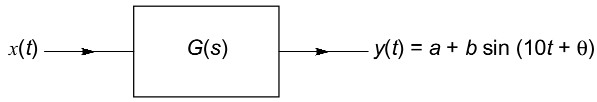
Possibilities, $\frac{s-1}{s+1}, \quad \frac{1-s}{1+s}$

Number of poles, $P = 1$

Number of zeros, $Z = 1$

End of Solution

Q.34



$$x(t) = 1 + 0.1\sin 10(t)$$

$$G(s) = \frac{100}{(s^2 + 0.1s + 100)}$$

The value of a and b will be

(a) $a = 1, b = 100$

(b) $a = 1, b = 100$

(c) $a = 1, b = 10$

(d) $a = 10, b = 1$

Ans. (c)

$$B = A|G(j\omega)|$$

$$a = 1\times\left|\frac{100}{100-\omega^2-0.1j\omega}\right|_{\omega=0} = 1$$

$$b = 0.1\times\left|\frac{100}{100-\omega^2-0.1j\omega}\right|_{\omega=10}$$

$$b = 0.1\times\left|\frac{100}{100-100-j0.1\times 10}\right| = 0.1\times\frac{100}{1}$$

$$b = 10$$

End of Solution

Q.35 For an ideal MOSFET biased in saturation, the magnitude of small signal current gain for a common drain amplifier is

(a) 1
(b) 100
(c) 0
(d) ∞

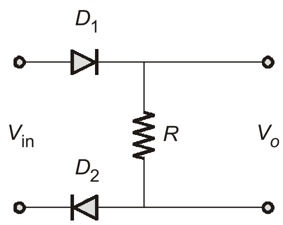
Ans. (d)

Voltage gain $A_V = 1$

Current gain, $A_I = \dfrac{i_s}{i_G} = \dfrac{i_s}{0} = \infty$

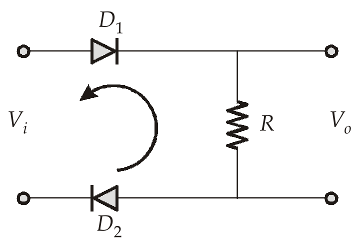
End of Solution

Q.36 In circuit shown diodes are ideal and input is sinusoidal. Find V_o.



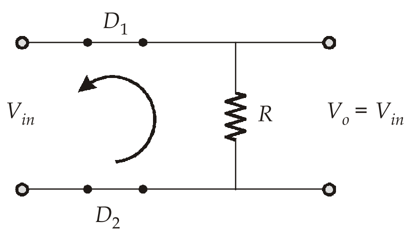
(a) $V_o = V_{in}$ for $V_{in} > 0$
(b) $V_o = -V_{in}$ for $V_{in} > 0$
(c) $V_o = -V_{in}$ for $V_{in} < 0$
(d) $V_o = V_{in}$ for $V_{in} < 0$

Ans. (a)



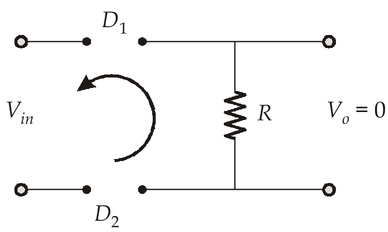
Positive half cycle

D_1 and D_2 will be ON.

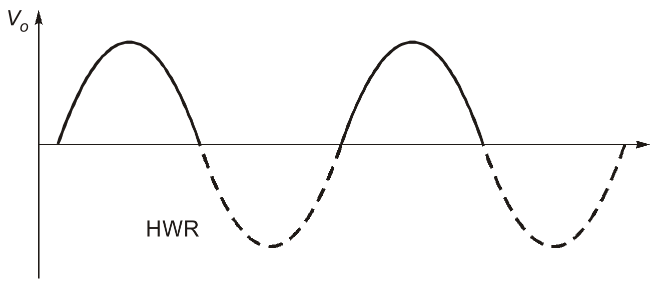


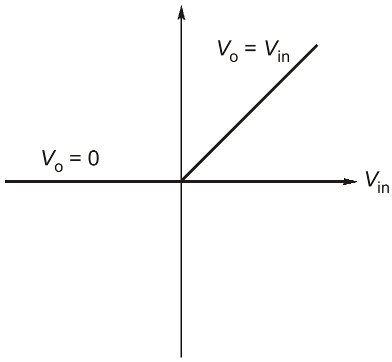
For Negative half cycle

D_1 and D_2 will be OFF.



The output waveform

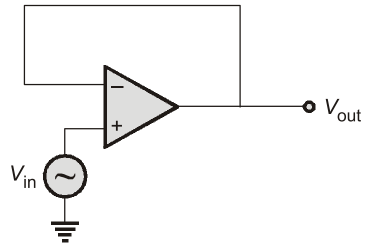


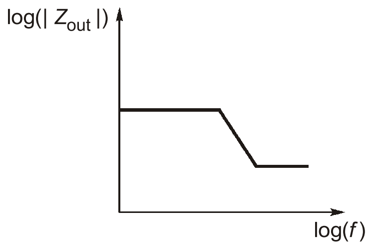


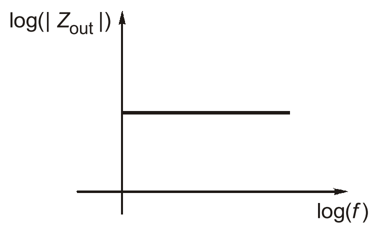
So, $V_o = V_{in}$ for $V_{in} > 0$

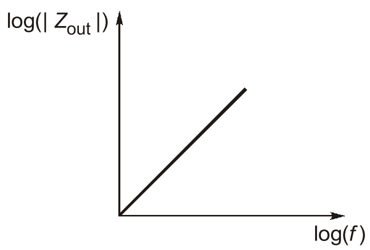
End of Solution

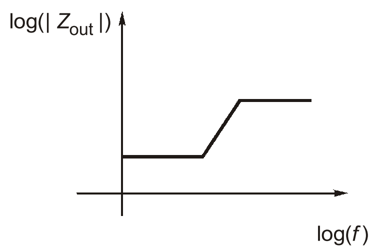
Q.37 The output impedance of non-ideal op-amp is denoted by Z_{out}. The variation in the magnitude of Z_{out} with increasing frequency f in the circuit shown below is best represented by



(a)


(b)


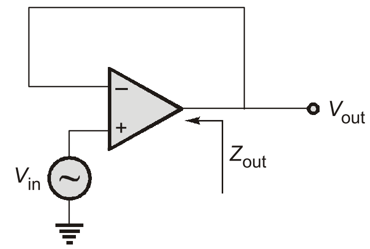
(c)


(d)


Ans. (d)

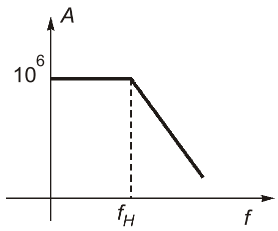
Analysis:

It is a voltage series feedback,

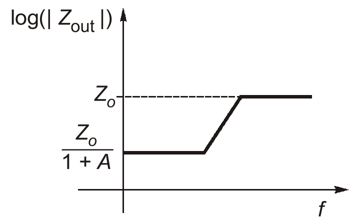


Voltage is a shunt connection,

$$Z_{out} \text{ feedback, } Z_{of} = \frac{Z_o}{1+A} = \frac{Z_o}{1+A} \qquad [\text{Buffer, } \beta = 1]$$



A = Open loop gain



A = constant (low frequency)

$$Z_{of} = \frac{Z_o}{1+A}[\text{Constant}]$$

A = Decreasing

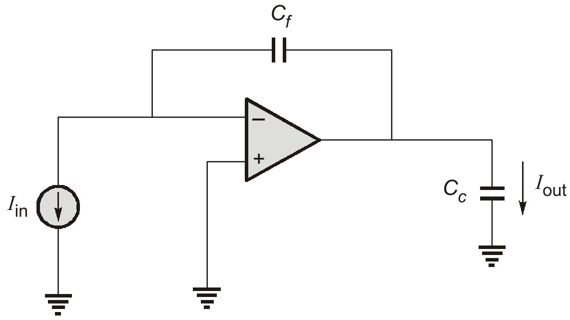
$$f \rightarrow \qquad Z_{of}\uparrow = \frac{Z_o}{1+A\downarrow}$$

$A = 0$

$$Z_{of} = \frac{Z_o}{1+0} = Z_o$$

End of Solution

Q.38 The current gain (I_{out}/I_{in}) in the circuit with an ideal current amplifier given below:



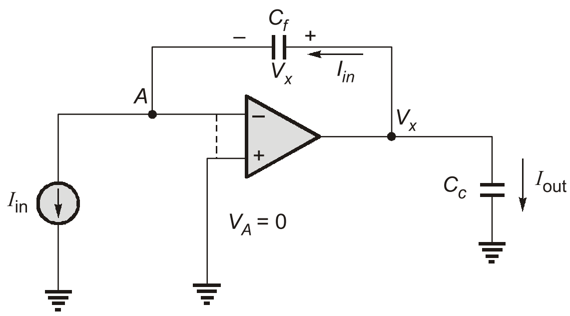
(a) $-\dfrac{C_F}{C_c}$

(b) $\dfrac{C_F}{C_c}$

(c) $\dfrac{C_c}{C_F}$

(d) $-\dfrac{C_c}{C_F}$

Ans. (c)



$$V_x = \frac{1}{C_f}\int I_{in} \times dt = \frac{I_{in}}{C_f} \times t$$

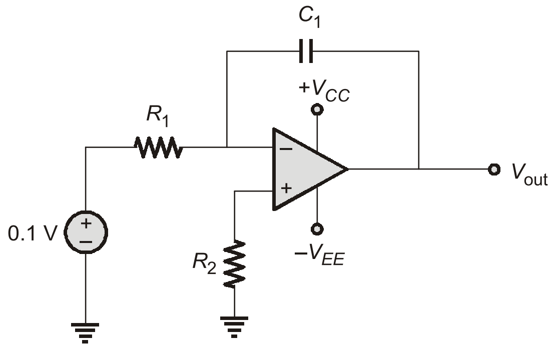
$$I_{out} = C_c \times \frac{dV_x}{dt} = C_c \times \frac{d}{dt}\left(\frac{I_{in}}{C_f} \times t\right)$$

$$= C_c \times \frac{I_{in}}{C_f}$$

$$\frac{I_{out}}{I_{in}} = \frac{C_c}{C_f}$$

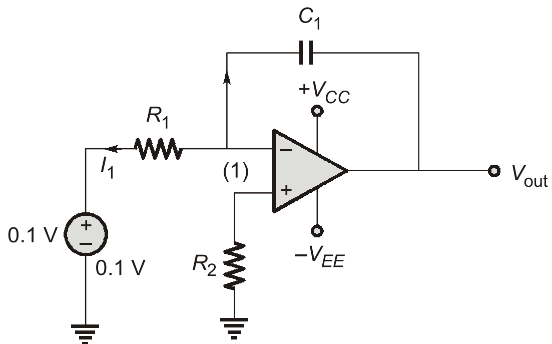
End of Solution

Q.39 Calculate V_o in the given op-amp circuit.



(a) 0.1 (b) $+V_{CC}$
(c) $-V_{EE}$ (d) -0.1 V

Ans. **(c)**



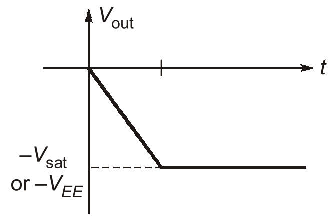
KCL at Node (i)

$$I_1 + I_2 = 0$$

$$\frac{V_1 - 0}{R_1} + C_1 \times \frac{d}{dt}(V_{out} - 0) = 0$$

$$\frac{dV_{out}}{dt} = -\frac{V_i}{R_1 C_1}$$

$V_A = 0$



$$V_{out} = -\frac{1}{R_1 C_1}\int V_i dt$$

$$V_i = 0.1 \text{ V}$$

$$V_{out} = -\frac{1}{R_1 C_1}\int_t 0.1 \times dt = -\frac{0.1}{R_1 C_1} \times t$$

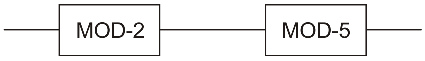
$$V_{out} = -k \times t$$

The output will be constant i.e. $-V_{EE}$.

End of Solution

Q.40 A MOD-2 and a MOD-5 up counter when cascaded together result in MOD ______ counter.

Ans. (10)



For overall configuration = Mod (2 × 5) = 10
It will be mod 10 counter.

End of Solution

Q.41 The maximum clock frequency in MHz of a 4 stage ripple counter utilizing flip flop with flip-flop having propagation delay of 20 nsec is ________ MHz.

Ans. (12.5)

$$T = nt_p = 4 \times 20\text{nsec} = 80 \text{ nsec}$$

$$\text{Clock frequency} = \frac{1}{T} = 12.5 \text{ MHz}$$

End of Solution

Q.42 $\bar{H} = x^2\hat{a}_x + x^2y^2\,\hat{a}_y + x^2y^2z^2\hat{a}_z$, $|\bar{J}|$ ______ at (1, 2, 1).

Ans. (12)

$$\therefore \quad \bar{J} = |\nabla \times \bar{H}|$$

$$\Rightarrow \quad \bar{J} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ x^2 & x^2y & x^2y^2z^2 \end{vmatrix}$$

$$= 2x^2yz^2\hat{a}_x - 2xy^2z^2\hat{a}_y + 2xy^2\hat{a}_z$$

$$\therefore \quad \bar{J}\Big|_{(1,2,1)} = 4\hat{a}_x - 8\hat{a}_y + 8\hat{a}_z$$

$$\Rightarrow \quad |\bar{J}| = 12 \text{ A/m}^2$$

End of Solution

Q.43 A long conducting cylindrical body having radius 'b' is placed on z-axis and $\vec{J} = J_o r^3\,\hat{z}$ for $r < b$. r is the radial distance. The value of H for $r < b$

(a) $\dfrac{J_o r^3}{3}$

(b) $\dfrac{J_o r^4}{4}$

(c) $J_o r^3$

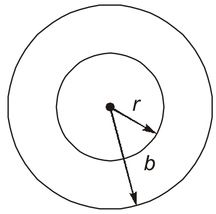
(d) $\dfrac{J_o r^4}{5}$

Ans. (d)

$$\oint \bar{H}\cdot \bar{dl} = I_{enc} = \int_s \bar{J}\cdot d\bar{s},$$

$$\bar{J} = J_0 r^3 \hat{a}_z$$

$$d\bar{s} = r\,dr\,d\theta\,\hat{a}_z$$

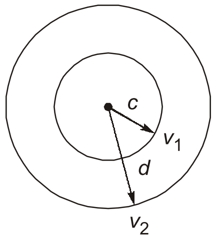


$$\Rightarrow \quad H\cdot 2\pi r = \int_{r=0}^{r}\int_{\phi=0}^{2\pi} J_0 r^3 \cdot r\,dr\,d\phi = \frac{J_0 r^5}{5}(2\pi)$$

$$\therefore \quad h = \frac{J_0 r^4}{5}$$

End of Solution

Q.44 The conducting sphere has potential v_1 at radius c and potential v_2 at radius d. The correct expression for potential between c and d will be



Ans. ()

For Laplace's equation,

$$\nabla^2 V = 0$$

For spherical co-ordinate system, $h_1 \quad h_2 \quad h_3$

$1 \quad r \quad r\sin\theta$

$$\Rightarrow \quad r^2\frac{dV}{\partial r} = A\ ;\ A = \text{constant}$$

$$\Rightarrow \quad \frac{dV}{\partial r} = \frac{A}{r^2}$$

$$\Rightarrow \quad V = -\frac{A}{r}+B;\ B = \text{constant}$$

at $r = c$; $\quad V = V_1$

$$\Rightarrow \quad V_1 = -\frac{A}{c}+B \qquad \text{...(i)}$$

at $r = d$;

$$\Rightarrow \quad V_2 = -\frac{A}{d}+B \qquad \text{...(ii)}$$

Equation (i) and (ii),

$$V_1 - V_2 = \frac{-A}{c}+\frac{A}{d}$$

$$\Rightarrow \quad V_1 - V_2 = A\left[\frac{c-d}{cd}\right]$$

$$\therefore \quad A = \left(\frac{V_1 - V_2}{c-d}\right)cd$$

and
$$B = V_1 + \frac{A}{c} = \frac{V_1}{c} \times cd\left[\frac{V_1 - V_2}{c-d}\right]$$

$$\Rightarrow \quad B = V_1 + d\left[\frac{V_1 - V_2}{c-d}\right]$$

$$V = \frac{-A}{r} + B$$

So,
$$V = \frac{-1}{r}\left(\frac{V_1 - V_2}{c-d}\right)cd + V_1 + \frac{d(V_1 - V_2)}{c-d}$$

End of Solution

Q.45 If $A = [a_{ij}]_{3\times3}$ such that $a_{ij} = (i-g)^3 \forall i \,\&\, j$, the A is ?

(a) Symmetric
(b) Skew symmetric
(c) Identity
(d) Null

Ans. (b)

$$A = [a_{ij}]_{3\times3},$$

$$a_{ij} = (i - j)^3$$
$$\Rightarrow \quad a_{11} = 0$$
$$a_{12} = (1 - 2)^3 = -1$$
$$a_{13} = (1 - 3)^3 = -8$$
$$a_{21} = (2 - 1)^3 = 1$$
$$a_{22} = (2 - 2)^3 = 0$$
$$a_{23} = (2 - 3)^3 = -1$$
$$a_{31} = (3 - 1)^3 = 8$$
$$a_{32} = (3 - 3)^3 = 1$$
$$a_{33} = (3 - 3)^3 = 0$$

$$A_{3\times3} = \begin{bmatrix} 0 & -1 & -8 \\ 1 & 0 & -1 \\ 8 & 1 & 0 \end{bmatrix}$$

$$\because \quad A^T = -A$$

So matrix A is skew symmetric.

End of Solution

Q.46 If $f(x) = ae^{-2|x|}$; $-\infty < x < \infty$ is p.d.f. for 'x', then what is the value of a?

Ans. (1)

Given $\quad f(x) = ae^{-2|x|}$, $x \in (-\infty, \infty)$ is p.d.f.

$$= \int_{-\infty}^{\infty} f(x)\,dx = 1$$

$$= \int_{-\infty}^{\infty} ae^{-2|x|}\,dx = \int_{0}^{\infty} ae^{-2(x)}dx = 1$$

$$= 2 \times \frac{a}{-2}\left[e^{-2x}\right]_0^{\infty} = 1$$

$$= \frac{2a}{2}[1-0] = 1$$

$\Rightarrow \quad a = 1$

End of Solution

Q.47 If $f(x) = \int_0^x e^t(t-1)(t-2)dt$, then $f(x)$ decreases in

(a) (0.5, 1)
(b) (0, 1)
(c) (1, 2)
(d) (2, 3)

Ans. (c)

By Leibnitz rule

$$f'(x) = \frac{d}{dx}\int_0^x e^t(t^2 + 3t + 2)dt < 2$$

$$= \left[e^x(x^2 - 3x + 2)(1) - e^0(0^2 + 0 + 2)(0)\right] < 0$$

$$= (x^2 - 3x^2 + 2) < 0$$

$\Rightarrow 1 < x < 2$

End of Solution

Q.48 If for the matrix $A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 4 & -2 \\ 0 & 1 & 1 \end{bmatrix}$,

$6A^{-1} = A^2 + CA + DI$, then $C + D$ = ?

Ans. (5)

The eigen value of given matrix are,

$$\lambda = 1,\ 1,\ 4$$

$$\frac{6}{\lambda} = \lambda^2 + C\lambda + D$$

So, $\lambda = 1$

$\Rightarrow$ $6 = 1 + C + D$

$\Rightarrow$ $C + D = 5$

End of Solution

Q.49 If $\vec{V} = x^2\hat{i} + +5y\hat{j} + 3z\hat{k}$ then evaluate $\iiint\left(\vec{\nabla}\cdot\vec{V}\right)dxdydz$ over the unit cube from $0 \le x \le 1,\ 0 \le y \le 1,\ 0 \le z \le 1$.

Ans. (9)

$$\vec{\nabla}\cdot\vec{V} = 2x + 5 + 3$$

$$\int_{x=0}^{1}\int_{y=0}^{1}\int_{z=0}^{1}(2x+8)dz\,dy\,dx = \int_0^1\int_0^1(2x+8)dy\,dx$$

$$= \int_0^1(2x+8)(y)_0^1dx = x^2+8x\Big]_0^1$$

$$= 9$$

End of Solution

Q.50 If $A_{n \times n}$ such that λ_A is an eigen value of A and V is the eigen vector corresponding to λ_A and consider following two statements:

S_1 : e^λ is an eigen value of e^A.

S_2 : V is an eigen vector of e^A then

(a) Both S_1 and S_2 and true

(b) Both false

(c) S_1 true, S_2 false

(d) S_1 false, S_2 true

Ans. (a)

$$e^A = 1 + A + \frac{A^2}{2} + ...$$

$$D = P^{-1}AP$$

$$\lambda_D = \lambda_A$$

So, $e^D = P^{-1}e^A\ P$

So, e^λ is eigen value of e^A.

Both are true.

End of Solution

Q.51 Consider the scalar point function $f(x,y,z) = 4x^2 + 7xy + 3xz^2$ then, at point $P(1, 0, 2)$, in which direction the directional derivative will be maximum?

(a) $20i$

(b) $20\hat{i} + 7\hat{j} + 12\hat{k}$

(c) $20\hat{i} + 12\hat{k}$

(d) $2\hat{i} + 7\hat{j} + 3\hat{k}$

Ans. (b)

$$f(x, y, z) = 4x^2 + 7xy + 3xz^2$$

$$\nabla f = \frac{\partial f}{\partial x}\hat{i} + \frac{\partial f}{\partial y}\hat{j} + \frac{\partial f}{\partial z}\hat{k}$$

$$\nabla f = (8x + 7y)\hat{i} + (7x)\hat{i} + (6xz)\hat{k}$$

at (1, 0, 2)

$$\nabla f(1, 0, 2) = (8 \times 1 + 2 \times 7)\hat{i} + (7 \times 1)\hat{i} + (6 \times 1 \times 2)\hat{k}$$

$$= (20\hat{i} + 7\hat{j} + 12\hat{k})$$

End of Solution

Q.52 Consider two dices having faces as P, Q, R, S, T, U, if both the dices are rolled together then what is the probability of getting any combination of P, Q, R on upper faces?

(a) $\frac{1}{4}$

(b) $\frac{1}{6}$

(c) $\frac{5}{36}$

(d) 0

Ans. (a)

$$n(s) = 6 \times 6 = 36$$

Total events,

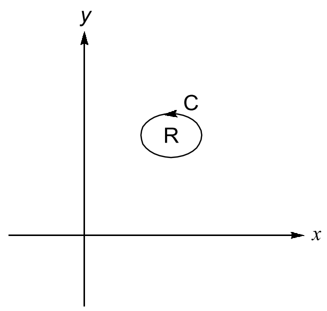
$$E = \{(P,P),(P,Q),(P,R),(Q,P),(R,P)(R,R)(Q,Q)(R,Q)(Q,R)\}$$

$$n(E) = 9$$

$$P(E) = \frac{n(E)}{n(s)} = \frac{9}{36} = \frac{1}{4}$$

End of Solution

Q.53 Region R is in first quadrant of xy-plane, which one of the following is not the area region 'R'?



(a) $\oint_C x dy$
(b) $\frac{1}{2}\oint_C x dy - y dx$
(c) $\iint_R dx dy$
(d) $\oint_C y dx$

Ans. **(a, d)**

By Green's theorem

$$\oint_c x\,dy - y\,dx = 2(\text{Area of region } R)$$

So, $$\frac{1}{2}(x\,dy - y\,dx) = (\text{Area of region } R)$$

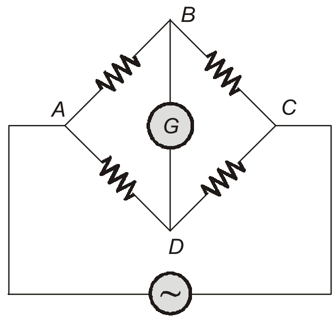
$$\oint x\,dy = \text{Area of } R \text{ bounded by } y\text{-axis.}$$

$$\oint y\,dx = \text{Area of } R \text{ bounded by } x\text{-axis.}$$

So, answer is (a) and (d).

End of Solution

Q.54



R_{AB} = 1 kΩ ± 2.1% , R_{BC} = 100 Ω ± 0.5%, R_{DA} = 300 ± 0.4%. Find the value of R_{CD} and accuracy.

(a) 30 ± 0.9 Ω
(b) 30 ± 9 Ω
(c) 3000 ± 90 Ω
(d) 3000 ± 9 Ω

Ans. **(a)**

Under balanced condition,

$$R_{CD} = \frac{R_{BC} \times R_{DA}}{R_{AB}} = \frac{(100 \pm 0.5\%)(300 \pm 0.4\%)}{(1000 \pm 2.1\%)}$$

$$R_{CD} = \frac{100 \times 300}{1000} + (0.5\% + 0.4\% + 2.1\%)$$

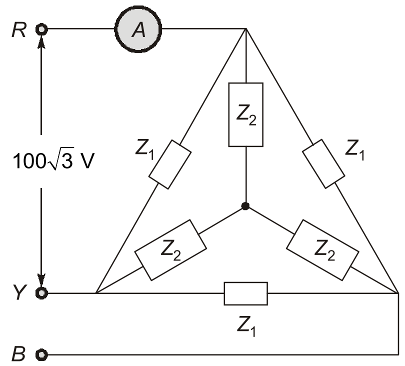
$$= 30 \pm 3\%$$

$$\% \text{ error} = \pm 3\%$$

$$R_{CD} = 30 \pm 30 \times \frac{3}{100} = 30 \pm 0.9\ \Omega$$

End of Solution

Q.55 Given that, $Z_1 = (j8 + j24)\Omega$, $Z_2 = (6 + j8)\Omega$. Find Ameter reading.

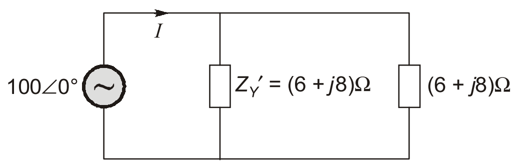


Ans. (20)

Convert Δ-Y conversion

$$Z_Y' = \frac{Z_\Delta}{3} = \frac{18 + j24}{3} = (6 + j8) \text{ ohm}$$

So per phase analysis,



So,
$$I = \frac{V_{ph}}{Z} = \frac{100}{(6+j8)} + \frac{100}{(6+j8)}$$

$$|I| = 20 \text{ Amp}$$

End of Solution

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