ACE
Engineering Academy

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ESE- 2018 (Prelims) - Offline Test Series — Test- 5

ELECTRONICS & TELECOMMUNICATION ENGINEERING

SUBJECT: CONTROL SYSTEMS & ELECTRO MAGNETICS
SOLUTIONS

01. Ans: (b)

Sol: $\tau = \frac{1}{50}$ sec

$$t_r \approx 2.2\tau = 2.2\times\frac{1}{50} = 0.044\,\text{sec}$$

02. Ans: (d)

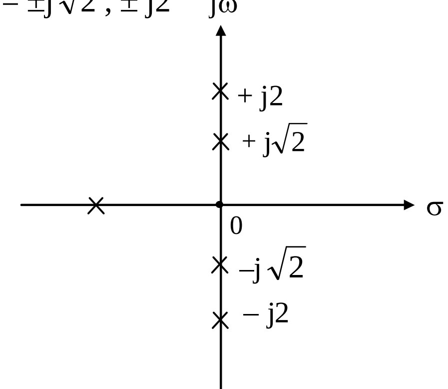
Sol: C.E $\Rightarrow s^5 + 7s^4 + 6s^3 + 42s^2 + 8s + 56 = 0$

s^5	1	6	8	
s^4	7(1)	42(6)	56(8)	
s^3	0(4)	0(12)	0	$\rightarrow$ Row of zero
s^2	3	8		
s^1	4/3			
s^0	8			

AE: $1s^4 + 6s^2 + 8 = 0$

Roots of AE $\Rightarrow (s^2+2)(s^2+4) = 0$

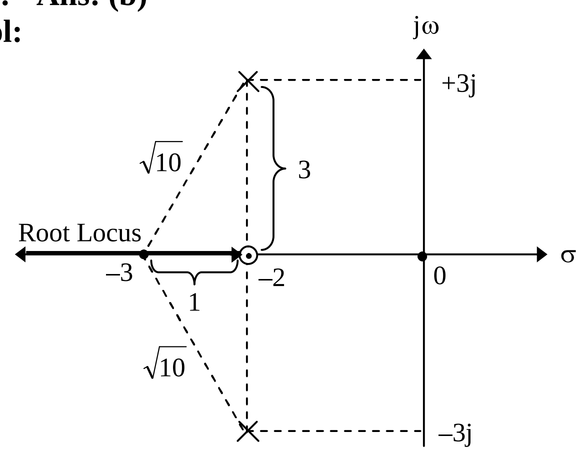
$s = \pm j\sqrt{2}, \pm j2$



$\Rightarrow$ 4-poles on jω-axis.

03. Ans: (b)

Sol:



$$k = \frac{\sqrt{10}\times\sqrt{10}}{1} = 10$$

04. Ans: (b)

Sol: $G(j\omega) = \dfrac{3(2-j\omega)}{(j\omega+1)(j\omega+5)} \Rightarrow M = \dfrac{3\sqrt{4+\omega^2}}{\sqrt{\omega^2+1}\sqrt{\omega^2+25}}$

ω = 0 magnitude M =1.2

$$\Rightarrow \phi = -\tan^{-1}\left(\frac{\omega}{2}\right) - \tan^{-1}(\omega) - \tan^{-1}\left(\frac{\omega}{5}\right)$$

ω = 0 ------- ϕ = 0°

ω = ∞ ------ ϕ = –270°

The polar starts at 1.2 ∠0° and ends at 0∠–270°

05. Ans: (d)

Sol: $G(s)\big|_{\omega_c} = \dfrac{50}{(s+4)(s+5)}\left[\dfrac{s^2k_d + sk_p + k_i}{s}\right]$

$= \dfrac{50(s^2k_d + sk_p + k_i)}{s(s+4)(s+5)}$

$\Rightarrow e_{ss} = \dfrac{A}{K_v} = \dfrac{1}{\frac{50\times k_i}{4\times 5}}$ [Given %e_{ss} = 10%, e_{ss} = 0.1]

$\Rightarrow 0.1 = \dfrac{20}{50k_i} \Rightarrow 5k_i = \dfrac{2}{0.1} = 20$

$k_i = 4$

06. Ans: (c)

Sol: $\Rightarrow \dfrac{C(s)}{R(s)} = \dfrac{G_1G_2G_3G_4}{1+G_4+G_3G_4+G_2G_3G_4+1+G_4+G_3G_4}$

$\dfrac{C(s)}{R(s)} = \dfrac{G_1G_2G_3G_4}{2+2G_4+2G_3G_4+G_2G_3G_4}$

07. Ans: (c)

Sol: CE is $1 + G(s) = 0$

$3s^3 + 10s^2 - as + ks + 2k = 0$

$3s^3 + 10s^2 + s(k-a) + 2k = 0$

s^3	3	(k-a)
s^2	10	2k
s^1	$\dfrac{10(k-a)-6k}{10}$	
s^0	2k	

For marginally stable $\Rightarrow \dfrac{10(k-a)-6k}{10} = 0$

10k – 10a – 6k = 0

4k = 10a ⇒ k = 2.5a……… (1)

AE is $10s^2 + 2k = 0$

s = j2

–40 +2k = 0 ⇒ k = 20……. (2)

(1) = (2)

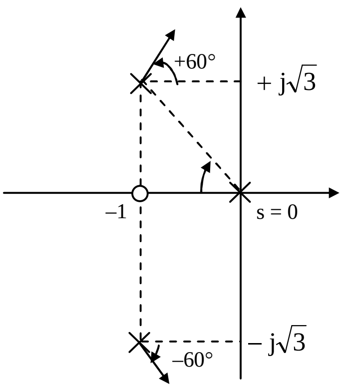
20 = 2.5 a ⇒ a = 8

08. Ans: (a)

Sol: $\angle GH(s)\big|_{s=-1+j\sqrt{3}} = \dfrac{\angle k\angle(s+1)}{\angle s\angle(s+1-j\sqrt{3})\angle(s+1+j\sqrt{3})}$

$= \dfrac{\angle k\angle j\sqrt{3}}{\angle(-1+j\sqrt{3})\angle 0\angle j2\sqrt{3}}$

$= \dfrac{0^\circ + 90^\circ}{120^\circ + 0^\circ + 90^\circ} = -120^\circ$

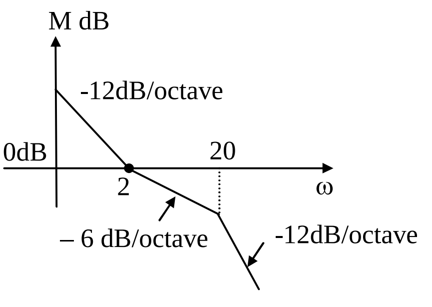


$\phi_d = 180^\circ + \angle GH = 180^\circ - 120^\circ = +60^\circ$

$\phi_d = \pm 60^\circ$

09. Ans: (c)

Sol:



± 20 dB/decade= ± 6 dB/octave

Initial slope = – 12 dB/octave

= – 40 dB/decade

⇒ two poles at origin

$T.F = G(s) = \dfrac{K\left(1+\frac{s}{2}\right)}{s^2\left(1+\frac{s}{20}\right)}$

At ω =2 ⇒ M_{dB} = 0dB

$20\log K - 20\log\omega^2\big|_{\omega=2} = 0\text{dB}$

$20 \log K - 20 \log 2^2 = 0$

$20 \log K = 20 \log 4$

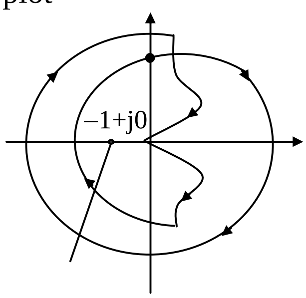
$\Rightarrow K = 4$

$$G(s) = \frac{4\frac{(s+2)}{2}}{\frac{s^2(s+20)}{20}} = \frac{40(s+2)}{s^2(s+20)}$$

10. Ans: (a)

Sol: Given, $G(s)H(s) = \dfrac{100}{s^3(s+10)}$

Nyquist plot



$N = -2$

(or) N = 2 in clockwise

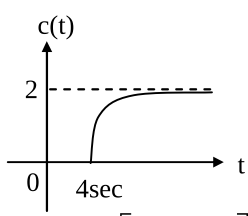
11. Ans: (d)

Sol: As system has one pole in the right half of s-plane, it is unstable.

$\therefore$ DC gain is infinite.

12. Ans: (d)

Sol:



$$c(\infty) = \underset{s\to 0}{Lt}\ s\left[\frac{ke^{-0.1sT_D}}{s+2}\right].\frac{e^{-3s}}{s} = \frac{k}{2}$$

From the plot, $c(\infty) = 2$

$\Rightarrow k = 4$

Delay $(0.1T_D + 3) = 4$

$$T_D = \frac{1}{0.1} = 10$$

$T_D = 10$

13. Ans: (a)

Sol: It is a lead controller, which increases the bandwidth.

14. Ans: (b)

Sol: Break point may exist any where on the s- plane.

15. Ans: (a)

Sol: $$\left|\frac{6}{(j\omega_{gc})^2(j\omega_{gc}+1)}\right| = 1$$

$\omega_{gc} = \sqrt{3}$ rad/sec

$$PM = 180° - 180° - \tan^{-1}\omega_{gc}\,\big|_{\omega_{gc}=\sqrt{3}} = -60°$$

$PM = -60°$

16. Ans: (b)

Sol: $\angle\dfrac{10}{j\omega - 1} = -(180° - \tan^{-1}\omega)$

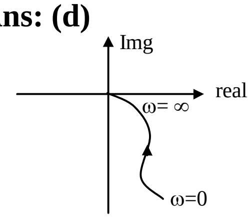
$\omega = 0$ ………. –180°

$\omega = 1$ …….. – 135°

$\omega = \infty$ …….. –90°

17. Ans: (d)

Sol:



18. Ans: (b)

Sol: $$\text{PI controller} = K_p\left[1 + \frac{1}{T_I s}\right]$$

$$= K_p\left[\frac{T_I s + 1}{T_I s}\right]$$

T_I = reset time

zero at $s = -\dfrac{1}{T_I} = -2$

$T_I = 0.5$sec

19. Ans: (b)

Sol: $G(s)H(s) = \dfrac{K(s+1)}{s^2(s+10)}$

No. of root loci that terminate at infinite are (P–Z) = 3–1 = 2

20. Ans: (c)

21. Ans: (a)

Sol: From the plot we can find that above system is type –1 system.

For unit step input, steady state error of type –1 system is zero.

22. Ans: (b)

23. Ans: (b)

Sol: OLTF = $\dfrac{10s+20}{s^2+20s+20-10s-20}$

$= \dfrac{10s+20}{s^2+10s}$

$k_v = \underset{s\to 0}{Lt}\ sG(s)\,H(s) = s\dfrac{10s+20}{s(s+10)} = 2$

$e_{ss} = \dfrac{A}{K_v}$ ($\because$ Unit ramp I/P)

$e_{ss} = 0.5$

24. Ans: (c)

25. Ans: (a)

Sol: C.E is 1+G(s) H(s) = 0

$s^2(s^3+4s^2+8s+8)+7s+4 = 0$

$s^5+4s^4+8s^3+8s^2+7s+4=0$

By Routh's tabulation,

$$\begin{array}{c|ccc}
s^5 & 1 & 8 & 7 \\
s^4 & 4(1) & 8(2) & 4(1) \\
s^3 & 6(1) & 6(1) & \\
s^2 & 1 & 1 & \rightarrow \text{Row of A.E} \\
s^1 & 2 & 0 & \\
s^0 & 1 & &
\end{array}$$

A.E is $s^2+1 = 0$, $\frac{dA}{ds} = 2s$

$s = \pm j$

$\omega = 1$ rad/sec

Two roots are on imaginary axis, 3 left hand Roots, 0 Right hand roots.

26. Ans: (c)

27. Ans: (c)

Sol: C.E is $s^5+4s^4+3s^3+(2+k)s^2+(s+4)k+7k = 0$

$s^5+4s^4+3s^3+2s^2+k(s^2+s+11) = 0$

$$1+\frac{k(s^2+s+11)}{s^5+4s^4+3s^3+2s^2} = 0$$

Number of roots tends to infinity = 5–2 = 3 because two roots tends to zeroes corresponding to $s^2+s+11 = 0$, remaining 3 roots tends to infinity.

28. Ans: (c)

Sol: Pairs of two non-touching loops are:

(c, mn), (c,lfn), (de, mn)

29. Ans: (b)

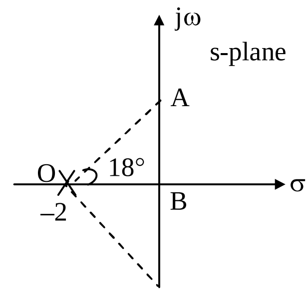
Sol: $G(s)H(s) = \frac{k}{(s+2)^{10}}$

$$\text{Centroid} = \frac{\Sigma\text{poles} - \Sigma\text{zeroes}}{p-z}$$

$$= \frac{(-2)10-0}{10} = -2$$

$$\text{Angle of asymptotes} = \frac{(2q+1)\pi}{p-z}$$

$= 18^\circ, 54^\circ$………...



$$\cos 18° = \frac{OB}{OA}$$

$$\Rightarrow OA = \frac{OB}{\cos 18^o} = \frac{2}{0.95} = 2.105$$

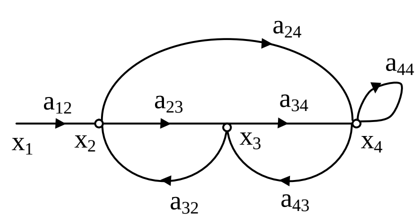
Maximum value of k for stability

$$= \frac{\text{product of distance from poles}}{\text{product of distance from zeroes}}$$

$= (2.105)^{10}$

30. Ans: (a)

Sol: Given signal flow graph is as below,



$x_4 = a_{24}\, x_2 + a_{34}\, x_3 + a_{44}\, x_4$

$x_4\,(1–a_{44}) = a_{24}\, x_2 + a_{34}\, x_3$

$x_4(1-a_{44}) = a_{24}\, x_2 + a_{34}\, x_3$

$$x_4 = \frac{a_{24}}{1-a_{44}}x_2 + \frac{a_{34}}{1-a_{44}}x_3$$

Option 'a' is correct

31. Ans: (d)

Sol: Lag compensator increases oscillatory response. In lag-lead compensator both lag and lead controllers are cascaded. So, statement 1, 2 are false.

32. Ans: (c)

Sol: By Final Value Theorem, $\underset{t\to\infty}{\mathrm{Lt}}\, f(t) = \underset{s\to 0}{\mathrm{Lt}}\, s.F(s)$

$$\frac{1}{2} = \underset{s\to 0}{\mathrm{Lt}}\, s.\frac{(s+1)}{s(s+K)}$$

$$\frac{1}{2} = \frac{1}{K}$$

$$\therefore K = 2$$

33. Ans: (a)

Sol: Circulation of the fields around any closed path for (1), (2) & (3) will gives zero and hence 1, 2 & 3 are conservative

Circulation of the field around any closed path for (4) is non-zero and hence it is non-conservative

34. Ans: (a)

Sol: Poisson's equation $\rightarrow \nabla^2 f + C_1 = 0$

Lapalce equation $\rightarrow \nabla^2 f = 0$

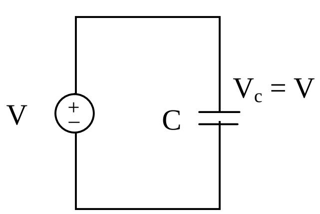
Helmholtz's equation $\rightarrow \nabla^2\vec{E} + k^2\vec{E} = 0$

Continuity equation $\rightarrow \nabla.\vec{J} = \frac{-\partial\rho_v}{\partial t}$

35. Ans: (b)

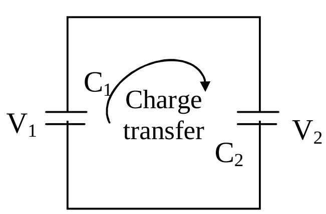
Sol:

(1)



$$W = \frac{1}{2}CV^2$$

(2)



The charge transfer takes place between C_1 and C_2 until $V_1 = V_2 = \frac{V}{2}$.

$\therefore C_{eq} = C_1 + C_2 = 2C$

$\therefore$ Energy stored $W' = \frac{1}{2}C_{eq}\left(\frac{V}{2}\right)^2$

$$= \frac{1}{2}(2C)\frac{V^2}{4}$$

$$W' = \frac{1}{2}\left(\frac{1}{2}CV^2\right)$$

$$W' = \frac{1}{2}W$$

36. Ans: (c)

Sol: Power loss per unit area $= \frac{1}{2}J_s^2 R_s$ and

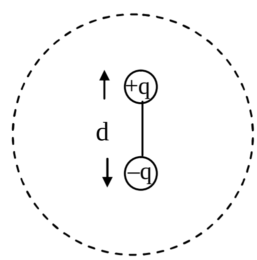
$$R_s = \sqrt{\frac{\omega\mu}{2\sigma}},\ R_s \propto \sqrt{\omega}$$

$\therefore$ Power loss per unit area decrease as frequency decreases.

37. Ans: (b)

Sol:

(1)



Flux leaving from Gauss's law

$$\oiint \overline{E}.\overline{dA} = \frac{+q-q}{\varepsilon}$$

$$\Rightarrow \oiint \overline{E}.\overline{dA} = 0$$

But E-field due to a dipole is

$$E = \frac{qd}{4\pi\varepsilon r^3}\left[2\cos\theta\hat{a}_r + \sin\theta\hat{a}_\theta\right]$$

$\therefore$ E $\neq$ 0 on the surface

(2) From above 'E' can not be zero at any point in space, since there is no value of 'θ' exists for which both sin and cos terms becomes zero.

(3) $V = \dfrac{qd\cos\theta}{4\pi\varepsilon r^2}$

$\theta = 90^o$ on bisecting plane

$\therefore V = 0$

38. Ans: (c)

Sol: If $\theta_I > \theta_c$ then total internal reflection takes place for both parallel and perpendicular polarization.

39. Ans: (a)

Sol: For $f < f_c$ the wave can not propagate in the wave guide and it gets attenuated along 'z'. This mode is called as "Evanescent mode".

⇒ For $f < f_c$, the waveguide has imaginary wave impedance, which in other word means that guide sees a reactive load that does not consume power.

40. Ans: (b)

Sol:

(i) E-field at centre of uniformly charged circular disk is not defined, because E-field is having discontinuity at the centre of disk.

(ii) $E = -\nabla V$ →always points from higher potential to lower potential.

(iii) $D = \varepsilon E = \varepsilon \dfrac{Q}{4\pi\varepsilon r^2} = \dfrac{Q}{4\pi r^2} C/m^2$

$\therefore$ 'D' is independent of 'ε'

41. Ans:(b)

Sol: → E-field can not be zero due to the two charges of same magnitude and opposite sign (polarity).

→ E-field will be zero exactly at the mid point for the two charges of same magnitude and polarity.

42. Ans: (c)

Sol: According to Faraday's law, when the conducting loop is rotating in a static magnetic field, then the induced emf is known as motional emf (or) dynamically induced emf. $V_{emf} = \oint_L \vec{v} \times \vec{B}.\, d\vec{\ell}$ (or)

magnitude of induced emf is given by $|V_{emf}| = B\ell v \sin\theta$ Volt

43. Ans: (c)

Sol: Time averaged Poynting vector is given by

$$\vec{W}_{avg} = \frac{E_{rms}^2}{\eta}\left(-\hat{a}_y\right)$$

$$\eta = 120\pi\sqrt{\frac{\mu_r}{\varepsilon_r}} = 120\pi\sqrt{\frac{2}{8}} = \frac{120\pi}{2}$$

$$\vec{W}_{avg} = \frac{(120\pi)^2}{120\pi \times \frac{1}{2}}\left(-\hat{a}_y\right) \times 10^{-6}$$

$$\therefore \vec{W}_{avg} = -240\pi\,\hat{a}_y\ \mu W/m^2$$

44. Ans: (a)

Sol: Given point: (1, 4, 3)

y-coordinate = 4, y > 0, hence this field point will be in the dielectric

Across conductor – dielectric interface

$$\vec{E} = \frac{\rho_s}{\varepsilon_0\varepsilon_r}\hat{a}_n$$

$$= \frac{\frac{1}{18\pi}\times 10^{-9}}{\frac{10^{-9}}{36\pi}\times 2}\left(+\hat{a}_y\right)$$

$$\therefore \vec{E} = \hat{a}_y\ \ V/m$$

45. Ans: (d)

Sol: From Faraday's law

$$\text{emf} = \oint_L \vec{E}.d\vec{\ell} = -N\frac{d\phi}{dt}$$

Assume N = 1 and $\phi = \int_S \vec{B}.d\vec{S}$

$$\oint_L \vec{E}.d\vec{\ell} = -\frac{d}{dt}\int_s \vec{B}.d\vec{S}$$

(or)

$$\oint_L \vec{E}.d\vec{\ell} = \int_S -\frac{d\vec{B}}{dt}.d\vec{S}$$

$$\text{(or)} \oint_C \vec{E}\,d\vec{\ell} = \iint -\frac{d\vec{B}}{dt}.d\vec{S}$$

46. Ans: (b)

Sol: From Ampere's law $\nabla \times \vec{H} = \vec{J}$

From Gauss's law $\nabla.\vec{D} = \rho_v$

Given medium is source free (i.e) $\vec{J} = 0$ & $\rho_v = 0$

$$\nabla \times \vec{H} = 0 \text{ and } \nabla \times \frac{\vec{B}}{\mu} = 0$$

$$\nabla.\vec{D} = 0 \text{ and } \nabla.\varepsilon\vec{E} = 0$$

As the medium is homogeneous

therefore $\nabla \times \vec{H} = 0$, $\nabla \times \vec{B} = 0$

$\nabla.\vec{D} = 0$ and $\nabla.\vec{E} = 0$ are correct form of Maxwell's equation

47. Ans: (c)

Sol: $I = \int_{\theta=0}^{\pi}\int_{\phi=0}^{2\pi} 6r\hat{a}_n . r^2 \sin\theta \, d\theta \, d\phi \, \hat{a}_n$

$= 6\, r^3\, (2)(2\pi)$

$= 6 \times 4\pi r^3 \times \left(\frac{3}{3}\right)$

$I = 18\left(\frac{4}{3}\pi r^3\right)$

$\therefore \oiint 6\vec{r}.ds\,\hat{a}_n = 18v$, when 'v' is volume of sphere.

48. Ans: (b)

Sol: In source-free region

$\nabla^2\phi = 0$

$\Rightarrow \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2} = 0$

$\Rightarrow 2 + 2 + 2C = 0$

$\Rightarrow 2C = -4$

$\therefore C = -2$

49. Ans: (b)

Sol: Potential at Y with respect to X is given by

$$V_{YX} = -\int_X^Y \vec{E}.d\vec{\ell}$$

$$= -\int_{X(2,0,0)}^{Y(1,2,3)} [xdx + ydy + zdz]$$

$$= -\left[\left.\frac{x^2}{2}\right|_2^1 + \left.\frac{y^2}{2}\right|_0^2 + \left.\frac{z^2}{2}\right|_0^3\right]$$

$$= -\left[\frac{1}{2}(1-4) + \frac{1}{2}(4) + \frac{1}{2}(9)\right]$$

$$= -\left[\frac{-3}{2} + \frac{4}{2} + \frac{9}{2}\right]$$

$\therefore V_{YX} = -5\text{Volt}$

50. Ans: (d)

Sol: Direction of propagation : –y

Transverse components are related as

$$\frac{E_x}{H_z} = -\frac{E_z}{H_x} = \sqrt{\frac{\mu}{\varepsilon}} = \frac{\omega\mu}{\beta} = \frac{\beta}{\omega\varepsilon}$$

$$\left(\frac{\omega\mu}{\beta} = \frac{\omega\mu}{\omega\sqrt{\mu\varepsilon}} = \sqrt{\frac{\mu}{\varepsilon}} \text{and} \frac{\beta}{\omega\varepsilon} = \frac{\omega\sqrt{\mu\varepsilon}}{\omega\varepsilon} = \sqrt{\frac{\mu}{\varepsilon}}\right)$$

$$\frac{\sqrt{E_x^2 + E_z^2}}{\sqrt{H_x^2 + H_z^2}} \equiv \eta = \sqrt{\frac{\mu}{\varepsilon}}$$

$\therefore$ statements 2, 3 & 4 are correct

51. Ans: (b)

Sol: Given $\omega = 2\pi \times 10^{10}$ rad/s

$\varepsilon_r = 25$

$\sigma = 5$ ℧/m

Loss tangent, $\frac{\sigma}{\omega\varepsilon} = \frac{5}{2\pi \times 10^{10} \times \frac{10^{-9}}{36\pi} \times 25}$

$= 36 \times 10^{-2}$

$= 0.36$

As $\frac{\sigma}{\omega\varepsilon} < 1$, hence the wave is travelling in a quasi dielectric.

52. Ans: (c)

Sol: Direction of propagation: x

Medium: lossless

$E_x = 0 = H_x$

Transverse components: E_y , H_z, E_z, H_y can exist

$$\frac{\partial^2 E_y}{\partial x^2} = \mu\varepsilon \frac{\partial^2 E_y}{\partial t^2}$$

$$\frac{\partial^2 E_z}{\partial x^2} = \mu\varepsilon \frac{\partial^2 E_z}{\partial t^2}$$

$$\frac{\partial^2 H_z}{\partial x^2} = \mu\varepsilon \frac{\partial^2 H_z}{\partial t^2}$$

$\frac{\partial^2 H_y}{\partial x^2} = \mu\varepsilon \frac{\partial^2 H_y}{\partial t^2}$ are the possible wave equation

53. Ans: (d)

Sol: Given: $Z_R = 120\Omega$

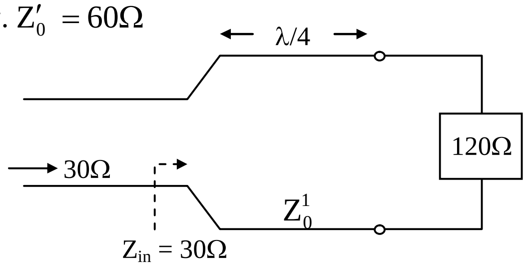
$Z_0 = 30\Omega$

The required characteristic impedance of quarter wave transformer is

$$Z_0' = \sqrt{Z_{in} Z_R}$$

$$= \sqrt{30 \times 120}$$

$$\therefore Z_0' = 60\Omega$$



54. Ans: (c)

Sol: For distortion less transmission line

$$\alpha = \frac{R}{L}\sqrt{LC} \text{ or } \frac{G}{C}\sqrt{LC}$$

$$= \frac{R}{\sqrt{\frac{L}{C}}}$$

$$\alpha = \frac{R}{Z_0} = \frac{0.5}{50}$$

α = 0.01Np/m

55. Ans: (c)

Sol: N: number of turns of solenoid

a: radius of solenoid

ℓ : length of solenoid

Magnetic field intensity at the centre is given by $H_{centre} = \frac{NI}{\ell}$

And at the upper end of solenoid is given by

$$H_{upper} = \frac{NI}{2\ell}$$

$$\frac{H_{center}}{H_{upper}} = \frac{\left(\frac{NI}{\ell}\right)}{\left(\frac{NI}{2\ell}\right)} = 2:1$$

56. Ans:(a)

Sol: Assume the circular loop is placed in z = 0 plane carrying a current in counter clockwise (anti clock wise) direction, then the magnetic field intensity at the centre of the loop is given by

$$\vec{H} = \frac{I}{2a}(\hat{a}_z) \text{ A/m}$$

Where 'a' is the radius of the loop

$$H_{ceter} \alpha \frac{1}{a}$$

Magnetic moment of the loop is

M = current × Area of the loop

$= I \times (\pi a^2)$

$\therefore M \ \alpha \ a^2$

Hence statement 1&2 are correct

57. Ans: (a)

Sol: Assume the direction of propagation: z

Longitudinal components: E_z & H_z (components along direction of propagation)

A TEM wave in which both E_z and H_z are zero

A TE mode in which $E_z = 0$, $H_z \neq 0$

A TM mode in which $H_z = 0$, $E_z \neq 0$

58. Ans: (b)

Sol: For lossless dielectric (α=0), so propagation constant $\gamma = j\beta$.

For conductor $\alpha = \beta = \sqrt{\frac{\omega\mu\sigma}{2}}$.

Perfect dielectric (σ = 0).

Surface impedance for good conductor,

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma}}$$

59. Ans: (c)

Sol: A quarter wave transformer used for matching purpose has two major limitation.

(1) It can only used to match real impedances.

(2) The matching is achieved in the very narrow frequency band with the condition that the ideal matching is achieved only at those frequencies where the length of the line is an odd multiple of quarter wave length i.e. $\ell = (2m+1)\lambda/4$.

60. Ans: (d)

Sol: $\frac{\sigma}{\omega\varepsilon} = 0.2$

$\Rightarrow \sigma = 2\pi f\varepsilon \times 0.2$

$= 2\pi \times 550 \times 10^3 \times 2.5 \times \frac{1}{36\pi} \times 10^{-9} \times 0.2$

$\therefore \sigma = 15.3 \times 10^{-6}$ S/m

61. Ans: (a)

Sol: $A_e = \frac{\lambda^2}{4\pi} D = \frac{900}{4\pi}\lambda^2 = 71.619\lambda^2$

62. Ans: (c)

Sol: A vector $\overline{F}$ is said to be solenoidal if $\nabla.\overline{F} = 0$ and is said to be rotational if $\nabla \times \overline{F} \neq 0$

63. Ans: (c)

Sol: For free space ($\sigma = 0$ and $\rho_v = 0$).

So $\nabla \times \overline{H} = j\omega\varepsilon\overline{E}$ and $\nabla.\overline{D} = 0$.

For both static and time-varying condition, $\nabla \times \overline{D} = \rho_v$.

For steady current $\nabla \times \overline{H} = \overline{J}$

64. Ans: (c)

Sol: $f_c\big|_{TM_{21}} = 18\text{GHz}$

$\eta\big|_{TM_{21}} = \eta\sqrt{1 - \left(\frac{f_c}{f}\right)^2}$

$= 377\sqrt{1 - \left(\frac{18}{30}\right)^2} = 301.6\Omega$

$\eta\big|_{TM_{21}} \approx 300\,\Omega$

65. Ans: (c)

Sol: $R_s = \sqrt{\frac{\omega\mu}{2\sigma}}$

$\delta = \sqrt{\frac{2}{\omega\mu\sigma}}$

$R_s\delta = \frac{1}{\sigma}$

$\Rightarrow \delta = \frac{1}{1.6 \times 10^7 \times 45 \times 10^{-3}}$

$= 1.4\mu m$

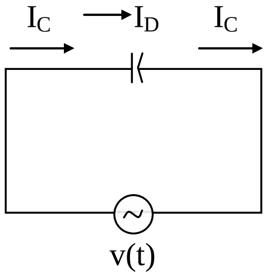
66. Ans: (a)

Sol: In time dependent situations E and H field are coupled to each other, and inside a conductor $E = \frac{J_C}{\sigma}$. Since σ is very high for conductor and E-field tends to zero, hence the coupled H-field will also tends to zero.

67. Ans:(b)

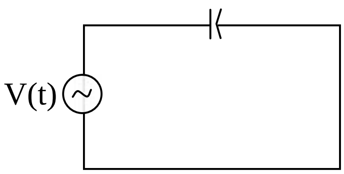
Sol: Statement (I):

The currents that are associated with the dielectric medium are displacement currents.



$\Rightarrow$ Displacement current 'I_D' will exist only if time varying voltage applied across the capacitor.

Statement (II):
If the medium between plate is not perfect dielectric ($\sigma \neq 0$) .



then $I = \dfrac{V}{Z}\angle 90^\circ - \tan^{-1}\left(\dfrac{\sigma}{\omega\varepsilon}\right)$

Where $|Z| = \dfrac{1}{\omega C\sqrt{1+\left(\dfrac{\sigma}{\omega\in}\right)^2}}$

68. Ans: (b)
Sol: Statement (I): For a TE polarized wave,

$$\sin^2\theta_B = 1 - \frac{\dfrac{\varepsilon_2\mu_1}{\varepsilon_1\mu_2}}{1-\left(\dfrac{\mu_1}{\mu_2}\right)^2}$$

For $\varepsilon_1 \neq \varepsilon_2$ and $\mu_1 = \mu_2 = \mu$, we doesn't have a solution as the right hand side of the above equation becomes infinite.

Statement (II):
For $\varepsilon_1 = \varepsilon_2 = \varepsilon$ and $\mu_1 \neq \mu_2$,

$$\sin^2\theta_B = \frac{1}{1+\dfrac{\mu_1}{\mu_2}} \Rightarrow \tan\theta_B = \sqrt{\frac{\mu_2}{\mu_1}}\ .$$

$\because\ \Gamma_\perp = 0 \Rightarrow \eta_2\cos\theta_i = \eta_1\cos\theta_t$

$$\Rightarrow \cos\theta_t = \sqrt{\frac{\mu_2}{\mu_1}}\cos\theta_i$$

We can prove $\theta_B + \theta_t = \dfrac{\pi}{2}$

If $\theta_B + \theta_t = \dfrac{\pi}{2}$ then $\cos(\theta_B + \theta_t) = 0$

Now,

$$\cos(\theta_B + \theta_t) = \cos\theta_B\cos\theta_t - \sin\theta_B\sin\theta_t \quad \text{--------(1)}$$

From Snell's law,

$$\sqrt{\mu_1}\sin\theta_B = \sqrt{\mu_2}\sin\theta_t$$

$$\Rightarrow \sin\theta_t = \sqrt{\frac{\mu_1}{\mu_2}}\sin\theta_B$$

Now (1) becomes,

$$\cos(\theta_B + \theta_t) = \cos^2\theta_B\sqrt{\frac{\mu_2}{\mu_1}} - \sin^2\theta_B\sqrt{\frac{\mu_1}{\mu_2}} \quad \text{-------------(2)}$$

Now , $\cos^2\theta_B = 1 - \sin^2\theta_B$

$$= 1 - \frac{1}{1+\dfrac{\mu_1}{\mu_2}}$$

$$= \frac{(\mu_2+\mu_1) - \mu_2}{\mu_1+\mu_2}$$

$$= \frac{\mu_1}{\mu_1+\mu_2}$$

Now substituting the above equation in (2), we get

$$\cos(\theta_B + \theta_t) = \frac{\mu_1}{\mu_1+\mu_2}\sqrt{\frac{\mu_2}{\mu_1}} - \frac{\mu_2}{\mu_1+\mu_2}\sqrt{\frac{\mu_1}{\mu_2}}$$

$$= \frac{1}{\mu_1+\mu_2}\left[\sqrt{\mu_1\mu_2} - \sqrt{\mu_1\mu_2}\right] = 0$$

69. Ans: (a)

Sol: Statement (I): If the medium is non-dispersive then the velocity does not depend on frequency. In this case we can define the velocity uniquely. So no need of the group velocity.

Statement (II):
In a dispersive medium different frequency components will travel with different velocities and hence shape of the waves becomes distorted. Here we will define both phase and group velocities.

70. Ans: (b)

Sol: $\text{Time constants} = \frac{1}{2}, \frac{1}{4}$

$= 0.5, 0.25$

$$C(\infty) = \underset{s\to 0}{\text{Lt}} \frac{s\times 10}{(s+2)(s+4)} \times \frac{1}{s}$$

$$= \frac{10}{8} = 1.25$$

71. Ans: (a)

Sol: $G(s) = \frac{K}{(1+sT)^2}$

$$K_v = \underset{s\to\infty}{\text{Lt}}\ s\times G(s) = 0$$

$$e_{ss} = \frac{1}{K_v} = \infty$$

72. Ans: (d)

Sol: For a second order system, for $0 < \zeta < 1$, system exhibits overshoot.

But for $0 < \zeta < \frac{1}{\sqrt{2}}$ only resonance peak exists.

So statement (I) is false.

73. Ans: (b)

Sol: Block diagram techniques used for simplification of control system, but for complicated systems, the block diagram reduction is tedious and time consuming hence signal flow graph used.
Signal flow graph is a graphical representation for the variables representing the output of the various blocks of the control system.

74. Ans: (a)

75. Ans: (a)