TEST ID: 510

ACE
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ESE- 2018 (Prelims) - Offline Test Series Test-20

GENERAL STUDIES

SUBJECT: ENGINEERING MATHEMATICS AND NUMERICAL ANALYSIS SOLUTIONS

01. Ans: (b)

Sol: $\int_0^{2\pi}|\cos x|dx = 2\int_0^{\pi}|\cos x|dx = 4\int_0^{\frac{\pi}{2}}|\cos x|dx$

$= 4\int_0^{\frac{\pi}{2}}(\cos x)\,dx = 4(\sin x)_0^{\frac{\pi}{2}}$

$= 4(1 - 0) = 4$

02. Ans: (a)

Sol: $\underset{x\to 2^-}{\text{Lt}} f(x) = \underset{x\to 2^+}{\text{Lt}} f(x) = \underset{x\to 2}{\text{Lt}} f(x) = 3$

$\therefore$ The above function is continuous at x = 2

but $f'(x) = \begin{cases} 1, & x \le 2 \\ -1, & x > 2 \end{cases}$

$\therefore \underset{x\to 2^-}{\text{Lt}} f'(x) = 1 \text{ and } \underset{x\to 2^+}{\text{Lt}} f(x) = -1$

i.e. f(x) is not differentiable at x = 2

03. Ans: (c)

Sol: $f'(x) = 3x^3 + 24x^2 + 45x$

$f'(x) = 0 \Rightarrow 3x(x^2 + 8x + 15) = 0$

$\Rightarrow 3x(x + 3)(x + 5) = 0$

$\therefore$ x = 0, –3, –5 are stationary points

$f''(x) = 3(3x^2 + 16x + 15)$

at x = 0, $f''(0) = 45 > 0$

$\therefore$ f(x) has a minimum at x = 0

at x = –3, $f''(0) = -18 < 0$

$\therefore$ f(x) has a maximum at x = –3

at x = –5, $f''(-5) = 30 > 0$

$\therefore$ f(x) has a minimum at x = –5

04. Ans: (b)

Sol: $\underset{x\to 0}{\text{Lt}} \dfrac{x(1 - a\cos x) + b\sin x}{x^3} = \dfrac{1}{3}$

$\Rightarrow \dfrac{1}{3} = \underset{x\to 0}{\text{Lt}} \dfrac{(1 - a\cos x) + a\,x\sin x + b\cos x}{3x^2}$

(Applying L-Hospital's rule) .... (1)

$\Rightarrow (1 - a + b) = 0$ .... (2)

$(\because \text{Limiting value is finite})$

Again by applying L-Hospitals rule two times,

$\dfrac{1}{3} = \underset{x\to 0}{\text{Lt}} \dfrac{a\sin x + a(\sin x + x\cos x) - b\sin x}{6x}$

$= \underset{x\to 0}{\text{Lt}} \dfrac{a\cos x + a(\cos x + x\sin + \cos x) - b\sin x}{6}$

$= \underset{x\to 0}{\text{Lt}} \dfrac{3a\cos x - a\,x\sin - b\cos x}{6}$

$= \dfrac{3a - b}{6}$

$\therefore (3a - b) = 2$ .... (3)

Solving (2) & (3) for a, b; we get,

$a = \dfrac{1}{2}$ & $b = \dfrac{-1}{2}$

05. Ans: (d)

Sol: By Green's theorem,

$$\int_C (x^2+xy)dx + (x^2+y^2)dy$$

$$= \int_{-1}^{1}\int_{-1}^{1}\left[\frac{\partial}{\partial x}(x^2+y^2) - \frac{\partial}{\partial y}(x^2+xy)\right] dx\,dy$$

$$= \int_{-1}^{1}\int_{-1}^{1}(2x-x)\,dx\,dy$$

$$= \int_{-1}^{1} x\,dx \int_{-1}^{1} dy$$

$$= \left(\frac{x^2}{2}\right)_{-1}^{1} (y)_{-1}^{1} = 0$$

06. Ans: (c)

Sol: Let $\phi(x, y, z) = (x^2 + y^2 + z^2)$

$\nabla\phi = (2x\,\bar{i} + 2y\,\bar{j} + 2z\,\bar{k})$

$(\nabla\phi)_{at\,(1,\,1,\,1)} = (2\bar{i} + 2\bar{j} + 2\bar{k}) = 2(\bar{i} + \bar{j} + \bar{k})$

A unit vector in the given direction

$$= \bar{a} = \frac{(\bar{i}+\bar{j}+\bar{k})}{\sqrt{1+1+1}} = \frac{1}{\sqrt{3}}(\bar{i}+\bar{j}+\bar{k})$$

$\therefore$ The required directional derivative

$$= (\nabla\phi.\ \bar{a})$$

$$= \frac{2}{\sqrt{3}}(1+1+1)$$

$$= \frac{2}{\sqrt{3}}(3) = 2\sqrt{3}$$

07. Ans: (d)

Sol: The auxiliary equation is $D^2 + 25 = 0$

$\Rightarrow D = \pm 5i$

$y = C_1 \cos 5x + C_2 \sin 5x$ .... (1)

at $x = 0, y = 1 \Rightarrow 1 = C_1 + 0$

at $x = \pi, y = -1 \Rightarrow -1 = C_1(-1) + 0$

$\Rightarrow C_1 = 1$

substituting C_1 value in (1), we have

$y = \cos 5x + C_2 \sin 5x$

08. Ans: (d)

Sol: If the partial differential equation

$$A\frac{\partial^2 p}{\partial x^2}+B\frac{\partial^2 p}{\partial x\,\partial y}+C\frac{\partial^2 p}{\partial y^2}+D\frac{\partial p}{\partial x}+E\frac{\partial p}{\partial y}=0$$

is parabolic,

then $B^2 - 4AC = 0$.

Here, A = 1, B = 4 and C = K

$$16 - 4 \times 1 \times K = 0 \Rightarrow 4K = 16$$

$$\Rightarrow K = 4$$

09. Ans: (b)

Sol: $4x^2\frac{d^2y}{dx^2}+y=0$

Let $x = e^t \Rightarrow \log x = t$

$4D_1(D_1 - 1)y + y = 0$ (where $D_1 = \frac{d}{dt}$)

$(4D_1^2 - 4D_1 + 1)y = 0$

The auxiliary equation is

$4D_1^2 - 4D_1 + 1 = 0$

$\Rightarrow (2D_1 - 1)^2 = 0 \Rightarrow D_1 = \frac{1}{2}, \frac{1}{2}$

$y = (C_1 + C_2 t)\, e^{\frac{t}{2}}$

$y = (C_1 + C_2 \log x)\, x^{\frac{1}{2}}$

10. Ans: (c)

Sol: $\frac{d^2y}{dt^2}-16y=e^{-4t}-\sin 4t$

$$\text{P. I.} = \left(\frac{1}{D^2-16}\right)\left(e^{-4t}-\sin 4t\right)$$

$$= t\left(\frac{1}{2D}\right)e^{-4t} - \frac{1}{-16-16}\sin 4t$$

$$= \frac{t}{-8}e^{-4t}+\frac{1}{32}\sin 4t$$

$$= -\frac{t}{8}e^{-4t}+\frac{\sin 4t}{32}$$

11. Ans: (d)

Sol: $\frac{dy}{dx}+1=e^{x+y}$

Let $x + y = v \Rightarrow 1 + \frac{dy}{dx} = \frac{dv}{dx}$

$\frac{dy}{dx}=\frac{dv}{dx}-1$

$\frac{dv}{dx}-1+1=e^v$

$\frac{dv}{dx}=e^v$

$e^{-v}\,dv = dx$

$-e^{-v} = x + c$

$x + e^{-(x+y)} = -C$

or

$x + e^{-(x+y)} = A$

12. Ans: (a)

Sol: $(x^2 + y^2 + 1)dx - 2xy\,dy = 0$

$$\frac{\frac{\partial M}{\partial y}-\frac{\partial N}{\partial x}}{N}=\frac{2y+2y}{-2xy}=\frac{4y}{-2xy}=\frac{-2}{x}$$

$\text{I. F} = e^{\int -\frac{2}{x}dx} = e^{-2\log x} = x^{-2}$

$\text{I. F} = \frac{1}{x^2}$

13. Ans: (a)

Sol: $$\text{P.I} = \left(\frac{1}{D^2+D-6}\right)x = \frac{1}{-6\left[1-\left(\frac{D^2+D}{6}\right)\right]}\,x$$

$$= -\frac{1}{6}\left[1-\left(\frac{D^2+D}{6}\right)\right]^{-1}x$$

$$= -\frac{1}{6}\left[1+\left(\frac{D^2+D}{6}\right)+.....\right]x$$

$$= -\frac{1}{6}\left(x+\frac{1}{6}\right) = -\frac{1}{36}(6x+1)$$

14. Ans: (c)

Sol: $\frac{dy}{dx} + \frac{y}{x} = x^2$

Integrating factor = $e^{\int \frac{1}{x} dx} = e^{\log x} = x$

The solution is

$y.\,x = \int x^2 .\, x\, dx + C$

$xy = \frac{x^4}{4} + C$

at $x = 1.\ y = 1 \Rightarrow 1 = \frac{1}{4} + C \Rightarrow c = \frac{3}{4}$

$x\,y = \frac{x^4}{4} + \frac{3}{4}$

$4\,xy = x^4 + 3$

15. Ans: (c)

Sol: A. E = $D^4 + 3D^2 = 0$

$D^2(D^2 + 3) = 0$

$D = 0, 0, D = \pm \sqrt{3}\, i$

$x = C_1 + C_2\, t + C_3 \cos \sqrt{3}\, t + C_4 \sin \sqrt{3}\, t$

16. Ans: (a)

Sol: $u = 2xy$

By C-R equations,

$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$ & $\frac{\partial u}{\partial y} = \frac{-\partial v}{\partial x}$

$dv = \frac{\partial u}{\partial x} dx + \frac{\partial u}{\partial y} dy = \frac{-\partial u}{\partial y} dx + \frac{\partial u}{\partial x} dy$

$\therefore\ v = \int\limits_{(y\,constant)} \frac{-\partial u}{\partial y} dx + \int\limits_{(free\,from\,x)} \frac{\partial u}{\partial x} dy + \text{Constant}$

$= \int -2x dx + \int 2y\, dy + \text{Constant}$

$= -x^2 + y^2 + \text{ Constant}$

17. Ans: (b)

Sol: for singularities

let $(z - 1)(z - 2) = 0 \Rightarrow z = 1, 2$

for zeros

let $z + 2 = 0 \Rightarrow z = -2$

18. Ans: (a)

Sol: $f(z) = \frac{1-e^{-z}}{z}$

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

$= \frac{1}{z}\left\{z-\frac{z^2}{2\,!}+\frac{z3}{3\,!}-.......\right\} = 1-\frac{z}{2!}+\frac{z^2}{3!}-........$

There are no negative power of z.

$\therefore$ z = 0 is a removable singularity

19. Ans: (d)

Sol: $f(z) = \frac{\alpha}{(z-1)(z+2)^2}$

z = –2 is pole of order '2'

(Res f(z): z = –2)

$= \frac{1}{(2-1)\,!}\underset{z\to-2}{\text{Lt}}\frac{d}{dz}\left[(z+2)^2\ f(z)\right] = -1$

$= \frac{1}{1}\underset{z\to-2}{\text{Lt}}\frac{d}{dz}\left[(z+2)^2\ \frac{\alpha}{(z-1)(z+2)^2}\right] = -1$

$= \underset{z\to-2}{\text{Lt}}\left[\frac{-\alpha}{(z-1)^2}\right] = -1$

$\frac{0-\alpha}{(-2-1)^2} = -1 \Rightarrow -\alpha = -9$

$\alpha = 9$

20. Ans: (b)

Sol: $f(z) = \frac{\sin z}{z^2} = \frac{1}{z^2}\left(z-\frac{z^3}{3!}+\frac{z^5}{5!}-\frac{z^7}{7!}+.......\right)$

$= \frac{1}{z}-\frac{z}{3!}+\frac{z^3}{5!}-\frac{z^5}{7!}+.......$

$\therefore$ coefficient of $z^3 = \frac{1}{5!} = \frac{1}{120}$

21. Ans: (d)

Sol: z = –1 is singularity and pole of order are one and it is inside of 'C'.

$\therefore$ Res f(z) at $z = -1\ \underset{z\to-1}{\text{Lt}}\ (z+1)\,f(z)$

$= 3(-1)^2 + 7(-1) + 1 = -3$

$\therefore \oint_C \frac{3z^2+7z+1}{z+1}\,dz = 2\,\pi\,i\,(-3) = -6\pi i$

22. Ans: (d)

Sol: z = 0 is a pole lies inside c: |z| = 1

$\oint_C \frac{e^{\frac{z^2}{2}}}{z^3}\,dz = 2\pi i\frac{\phi''(0)}{2!}$ .... (1)

where

$\phi(z) = e^{z^2}$

$\phi'(z) = 2z\ e^{z^2}$, $\phi''(z) = (2z)^2\ e^{z^2} + 2\,e^{z^2}$

$\phi''(0) = 2$

$\therefore \oint_C \frac{e^{\frac{z^2}{2}}}{z^3}\,dz = \frac{2\pi i(2)}{2} = 2\pi\,i$

23. Ans: (b)

Sol: $f(z) = \frac{z^2-2z}{(z+1)^2\,(z^2+4)}$

z = –1 is a pole of order 2

$\underset{z=-1}{\text{Res}}\ f(z) = \underset{z\to-1}{\text{Lt}}\frac{d}{dz}\left\{(z+1)^2\ \frac{z^2-2z}{(z+1)^2\,(z^2+4)}\right\}$

$= \underset{z\to-1}{\text{Lt}}\left\{\frac{(z^2+4)(2z-2)-(z^2-2z)(2z)}{(z^2+4)^2}\right\}$

$= \frac{(5)(-4)-(3)(-2)}{25} = \frac{-14}{25}$

24. Ans: (a)

Sol: u = x + ay   v = bx + cy

$\frac{\partial u}{\partial x} = 1$ $\frac{\partial v}{\partial x} = b$

$\frac{\partial u}{\partial y} = a$ $\frac{\partial v}{\partial y} = c$

C–R equations must be satisfied

$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$ & $\frac{\partial u}{\partial x} = -\frac{\partial v}{\partial x}$

c = 1 & a = –b

25. Ans: (c)

Sol: Combined $\overline{X} = \dfrac{n_1\overline{X}_1 + n_2\overline{X}_2 + n_3\overline{X}_3}{n_1 + n_2 + n_3}$

$$\overline{X}_2 = \frac{300\times 45 - 100\times 70 - 100\times 20}{100} = \frac{4500}{100}$$

$= 45$

26. Ans: (c)

Sol: $\sigma^2 = \dfrac{\sum x_i^2}{n} - (\overline{x})^2$

$$= \frac{169}{10} - \left(\frac{12}{10}\right)^2 = 1.69 - (1.2)^2 = 0.25$$

27. Ans: (b)

Sol: For sum to be 7: {(1, 6) (6, 1) (5, 2) (2, 5) (4, 3) (3, 4)}

Number of favourable cases = 2

Required probability = $\dfrac{2}{6}$

28. Ans: (d)

Sol:

Required Probability = $1 - P(5 \cup 6)$

$$= 1 - \left[\frac{6}{30} + \frac{5}{30} - \frac{1}{30}\right]$$

$$= \frac{20}{30}$$

29. Ans: (a)

Sol: $n(S) = 2^5$

Required probability = P(2 heads and 3 tails) + P(3 heads and 2 tails)

$$= \frac{5C_2 + 5C_3}{2^5} = \frac{10+10}{2^5}$$

$$= \frac{20}{2^5}$$

30. Ans: (a)

Sol: Required probability

$$= P(A \cup B) - P(A \cap B)$$

$$= \frac{11}{20} - \frac{10}{20} = \frac{1}{20}$$

31. Ans: (a)

Sol: Given that, $P(M \cup S) = \frac{7}{10}$;

$$P(M \cap S) = \frac{2}{5};\ P(M/S) = \frac{2}{3}$$

Required probability = 1 – P(S)

$$= 1 - \left(\frac{P(M \cap S)}{P(M/S)}\right) = 1 - \frac{2/5}{2/3} = \frac{2}{5}$$

$$\left(\because P(M/S) = \frac{P(M \cap S)}{P(S)}\right)$$

32. Ans: (a)

Sol: $E(X) = (0 \times P) + (2P) + 1\,(1 - 2P) = 1$

33. Ans: (b)

Sol: $E(X^2) = \int_{-4}^{4} x^2\,|x|\ dx$

$$= 2\int_0^4 x^3\ dx$$

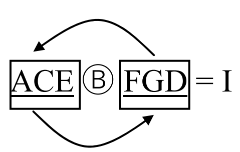
$$= 2\left[\frac{x^4}{4}\right]_0^4 = 2\left[\frac{4^4}{4}\right]$$

$$= 2[4^3] = 128$$

34. Ans: (c)

Sol:

Short cut solution:



B^{-1} = FGDACE

Solution: Given that ACEBFGD = I

$\Rightarrow ACEB = D^{-1}\,G^{-1}\,F^{-1}$

$\Rightarrow B = E^{-1}\,C^{-1}\,A^{-1}\,D^{-1}\,G^{-1}\,F^{-1}$

$\Rightarrow B^{-1}$ = FGDACE

35. Ans: (b)

Sol: $A^2 = I$

$|A^2| = |I|$

$|A^2| = 1$

$|A| = \pm 1$

$\therefore\ |A| \neq 0$

$\Rightarrow$ A is non-singular matrix

$\therefore\ \rho(A) = n$ and $\rho(A|B) = n$

$\rho(A) = \rho(A|B)$ = number of unknowns

$\therefore$ The system has a unique solution.

36. Ans: (b)

Sol: $|A| = \begin{vmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{vmatrix} = 0$

$\rho(A) < 3$ (Number of unknowns)

$\therefore$ It has non-trivial solution

Rank of A = 2

$\Rightarrow$ The system has only one independent solution

37. Ans: (c)

Sol: Number of Linear independent solutions

$$= n - r = n - \rho(A)$$

$$= 4 - 1 = 3$$

$$A = \begin{bmatrix} 1 & 2 & 3 & -2 \\ 3 & 6 & 9 & -6 \\ 2 & 4 & 6 & -4 \end{bmatrix}$$

$R_1 - 3R_1$, $R_3 - 2R_1$

$$A \sim \begin{bmatrix} 1 & 2 & 3 & -2 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\therefore\ \rho(A) = 1$

38. Ans: (b)

Sol: Trace A = 2 + y

4 + 8 = 2 + y

y = 10

|A| = 2y – 3x

4×8 = 2y – 3x

32 = 20 – 3x

⇒ x = –4

39. Ans: (d)

Sol: Given that eigen values of A are 1, –1, 0

The eigen values of $(A^{25} + 5I)$ are $1^{25} + 5$, $(-1)^{25} + 5$, $0^{25} + 5$

i.e. 6, 4 and 5

$|A^{25} + 5I| = 4 \times 5 \times 6 = 120$

40. Ans: (c)

Sol: Let $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$

AX = λX

$\begin{bmatrix} a & b \\ c & d \end{bmatrix}\begin{bmatrix} 1 \\ -1 \end{bmatrix} = 1\begin{bmatrix} 1 \\ -1 \end{bmatrix}$

a – b = 1

c – d = –1

AX = λX

$\begin{bmatrix} a & b \\ c & d \end{bmatrix}\begin{bmatrix} 2 \\ 1 \end{bmatrix} = 4\begin{bmatrix} 2 \\ 1 \end{bmatrix}$

2a + b = 8

2c + d = 4

a = 3, b = 2

c = 1, d = 2

41. Ans: (d)

Sol: Number of Linear Independent eigen vectors

= n – ρ(A – λI)   λ = 100

= 4 – ρ(A – 100I)

= 4 – 0

= 4

42. Ans: (b)

Sol:

$(A + I)^{-1} (A + 5I) = (A + I)^{-1}[(A + I) + 4I]$

$= [(A+I)^{-1} (A+I) + 4(A+I)^{-1}]$

$(A + I)^{-1} (A + 5I) = I + 4(A+I)^{-1}$

Given that, eigen values of A are –2 and –3.

∴ Eigen values of $[I + 4(A+I)^{-1}]$ are

$1 + 4(-2 + 1)^{-1}$, $1 + 4(-3 + 1)^{-1}$

i.e. –3 and –1

43. Ans: (a)

Sol: Error = 0

Simpson $\frac{1}{3}$ gives exact result for polynomial of degree 2.

44. Ans: (a)

45. Ans: (b)

Sol: The Newton- Raphson iteration formula is

$x_{n+1} = x_n - \frac{f(x_n)}{f'(x)}$ where $f(x) = x^2 - 2$

$\Rightarrow x_{n+1} = \frac{x_n^2 + 2}{2x_n}$

$x_1 = \frac{x_0^2 + 2}{2x_0} = \frac{(1)^2 + 2}{2(1)} = 1.5$

46. Ans: (b)

47. Ans: (c)

Sol: In Newton Raphson method, if the graph of f(x) is horizontal to x-axis then we cannot draw tangent. So we cannot find better approximation.

48. Ans: (c)

Sol: If f(a).f(b) > 0 then we have no root (or) even number of roots.

49. Ans: (b)

Sol: In Newton Raphson method, we have $e_{n+1} = k\,e_n^2$ so, it has Quadratic convergence

50. Ans: (a)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