N.B. : 1. Question No. 1 is **compulsory**.
2. Attempt any **four** questions out of remaining **six** questions.
3. Assume any suitable data, wherever **required** but justify the **same**.
4. **Figures** to the **right** indicate **full** marks.

1. (a) Define Laplace transforms, and If $L\{f(t)\} = f(s)$ and $g(t)$ is a function defined as — 5

$$g(t) = \begin{cases} 0, & 0 < t < a \\ f(t-a), & t > a \end{cases}$$ then prove that $L\{g(t)\} = e^{-as} f(s)$

(b) Determine the value of b such that the rank of A is 3 where $A = \begin{bmatrix} 1 & 1 & -1 & 0 \\ 4 & 4 & -3 & 1 \\ b & 2 & 2 & 2 \\ 9 & 9 & b & 3 \end{bmatrix}$ — 5

(c) If $w = f(z)$ is analytic then show that $|f'(z)|^2 = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix}$ — 5

(d) Express $f(x) = \frac{1}{2}(\pi - x)$ in a Fourier series with period 2π to be valid in the interval $(0, 2\pi)$. — 5

2. (a) Find (1) $L\left\{\left(\sqrt{t} + \frac{1}{\sqrt{t}}\right)^3\right\}$ (2) $L\{e^{2t} \sin^4 t\}$ — 5

(b) Find the Fourier series of $f(x) = x^2$, $0 < x < 4$ and hence deduce that — 5

$$\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \ldots\ldots = \frac{\pi^2}{6}$$

(c) Determine P such that the function $f(z) = \frac{1}{2}\log(x^2 + y^2) + i\tan^{-1}\frac{px}{y}$ is analytic. — 5

(d) Using row transformations find the inverse of the matrix $A = \begin{bmatrix} 2 & 3 & 4 \\ 4 & 3 & 1 \\ 1 & 2 & 4 \end{bmatrix}$ — 5

3. (a) Using Laplace transforms show that $\int_0^\infty e^{-\sqrt{2}t} \frac{\sinh t \sin t}{t} dt = \frac{\pi}{8}$. — 5

(b) Reduce the matrix $A = \begin{bmatrix} 1 & 2 & -2 & 3 & 1 \\ 1 & 3 & -2 & 3 & 0 \\ 2 & 4 & -3 & 6 & 4 \\ 1 & 1 & -1 & 4 & 6 \end{bmatrix}$ — 5

to the normal form and hence find its rank.

(c) Find the Fourier series expansion of the function— 5

$$f(x) = \pi x, \quad 0 \le x \le 1$$
$$= \pi(2 - x), \quad 1 \le x \le 2$$

(d) If $f(z) = u + iv$ be analytic function of $z = x + iy$, and $u - v = (x - y)(x^2 + 4xy + y^2)$ — 5
then find $f(z)$.

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4. (a) Find non-singular matrix P and Q so that PAQ is a normal form where

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

(b) Find (1) $L^{-1}\left\{\frac{s^2}{\left(s^2+a^2\right)^2}\right\}$ (2) $L^{-1}\left\{\frac{s+29}{(s+4)\left(s^2+9\right)}\right\}$.

(c) If $u = \lambda(1+\cos\theta)$ then find V so that u + iv is analytical.

(d) Obtain half range sine series for f(x).

where $f(x) = mx, \; 0 \le x \le \pi/2$

$$= m(\pi - x), \; \frac{\pi}{2} \le x \le \pi.$$

5. (a) Show that the transformation $w = \frac{2z+3}{z-4}$ maps the circle $x^2 + y^2 - 4x = 0$ into s.t. line $4u + 3 = 0$.

(b) Use convolution theorem to find $L^{-1}\left\{\frac{(s+2)^2}{\left(s^2+4s+8\right)^2}\right\}$.

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(d) Show that the set of functions $e^{\frac{x}{2}}, e^{-\frac{x}{2}}(1-x), e^{-\frac{x}{2}}(2-4x+x^2)$ are orthogo over $(0, \infty)$.

6. (a) Find the Bilinear transformation which maps the points. 1, i, – 1 of z-plane on i, 0, – i of w-plane and find the fixed pt's of this transformation.

(b) If A is non-singular matrix of order n, prove that —

(1) $A(\text{adj } A) = (\text{adj } A)A = |A| I_n$ (2) $|\text{adj } A| = |A|^{n-1}$

(c) Obtain complex form of Fourier series for $f(x) = \cosh 3x + \sinh 3x$ in (– 3, 3

(d) Solve $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 5y = e^{-t}\sin t$ with $y(0) = 0$ and $y'(0) = 1$ by Laplace transf method.

7. (a) If f(t) is a periodic function of period T, show that $L\{f(t)\} = \frac{1}{1-e^{-sT}}\int_0^T e^{-st} f(t$

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(c) If the matrix $A = \begin{bmatrix} 4 & 3 & -2 \\ -1 & 0 & 1 \\ 2 & 3 & 4 \end{bmatrix}$ then show that adj A is symmetric.

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6. (a) Find the Bilinear transformation which maps the points. 1, i, – 1 of z-plane on i, 0, – i of w-plane and find the fixed pt's of this transformation.

(b) If A is non-singular matrix of order n, prove that —
(1) $A(\text{adj } A) = (\text{adj } A)A = |A| I_n$ (2) $|\text{adj } A| = |A|^{n-1}$

(c) Obtain complex form of Fourier series for $f(x) = \cosh 3x + \sinh 3x$ in $(-3, 3$

(d) Solve $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 5y = e^{-t}\sin t$ with $y(0) = 0$ and $y'(0) = 1$ by Laplace transf method.

7. (a) If f(t) is a periodic function of period T, show that $L\{f(t)\} = \frac{1}{1-e^{-sT}}\int_0^T e^{-st} f(t$

(b) If u is a regular function, then prove that— $\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)|f'(z)|^2 = 4|f'(z)$

(c) Test the consistency of following system of equation and solve them if possib

$6x + y + z = -4$
$2x - 3y - z = 0$
$-x - 7y - 2z = 7.$

(d) Expand $f(x) = a\left(1 - \frac{x}{l}\right)$ in the range $(0, l)$ in a half range cosine series.