PANIMALAR ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University Chennai)

QUESTION BANK

Details of the Course

Name of the Department	**: MATHEMATICS**
Name of the Course	**: COMPLEX VARIABLES AND TRANSFORMS**
Course Code	**: 23MA1206**
Semester	**: II**
Common To Programme(s)	**: CSE & IT**

Instructions

Blooms Level: Blooms Level 1 & 2 is Lower Order (LO) Cognitive type, Blooms Level 3 & 4 is Intermediate Order Cognitive Type (IO) and Blooms Level 5 & 6 is Higher Order (HO) cognitive type.

2 Marks: For **each unit five questions should be of lower order (LO)** cognitive type and **five Questions should be of Intermediate order (IO)** cognitive type.

13 /15 /16 Marks: For each Unit **four questions should be of lower order (LO) cognitive type** i.e. remembrance type questions, **five should be of intermediate order** (IO) cognitive type i.e. understanding type questions and **One Question should be on Higher Order (HO)** Application / Design / Analysis / Evaluation / Creativity / Case study questions.

* HO Order is not applicable if the Question Pattern does not have Part C. In Such cases consider HO as IO.

** If the Mark for Part B &C is less than the maximum mark of the Question, Sub Divisions shall be added.

Course Outcome: (List the Course Outcomes of the Course)

CO1: Gradient, divergence and curl of a vector point function and related identities. Evaluation of line, surface and volume integrals using Gauss, Stokes and Green's theorems and their verification.
CO2: Understanding analytic functions, harmonic functions, conformal mapping.
CO3: Determine the types of singularities, residues, contour integration.
CO4: Determine the Fourier transforms for a function and evaluates special integrals.
CO5: Solve differential equations using laplace transforms.

Bloom's Level: **BL1** - Remembering, **BL2** - Understanding, **BL3** - Applying, **BL4** - Analyzing, **BL5**– Evaluating, **BL6** - Creating.

Diagrams, Table Values, Equations must be legible and clear.

UNIT- I – VECTOR CALCULUS				
	PART A (2 Marks)	**Bloom's Level**	**Course Outcome**	**Marks Allotted**
1.	Find the directional derivative of $\varphi = x^2yz + 4xz^2$ at $(1, -2, -1)$ in the direction of $2\vec{i} - \vec{j} - 2\vec{k}$.	[BL1]	[CO1]	[2]
2.	Find a unit normal to the surface $\mathrm{xy} = \mathrm{z}^2$ at the point (1, 1,-1).	[BL2]	[CO1]	[2]
3.	Find $\nabla(r^n)$.	[BL1]	[CO1]	[2]
4.	Find (i) $\nabla.\vec{r}$ (ii) $\nabla \times \vec{r}$	[BL2]	[CO1]	[2]
5.	Prove that the vector $\vec{F} = z\vec{i} + x\vec{j}+y\vec{k}$ is solenoidal.	[BL2]	[CO1]	[2]

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6.	Prove that the vector $\vec{F} = yz\vec{i} + zx\vec{j} + xy\vec{k}$ is irrotational.	[BL1]	[CO1]	[2]
7.	Find 'a' such that $(3x - 2y + z)\vec{i} + (4x + ay - z)\vec{j} + (x - y + 2z)\vec{k}$ is solenoidal.	[BL3]	[CO1]	[2]
8.	Find the constants a,b,c so that $\vec{F} = (x + 2y + az)\vec{i} + (bx - 3y - z)\vec{j} + (4x + cy + 2z)\vec{k}$ is irrotational.	[BL3]	[CO1]	[2]
9.	If $\vec{F} = x^3\vec{i} + y^3\vec{j} + z^3\vec{k}$ then find div (curl $\vec{F}$).	[BL2]	[CO1]	[2]
10.	State the physical interpretation of the line integral $\int_A^B \vec{F} \cdot d\vec{r}$.	[BL2]	[CO1]	[2]
Descriptive Questions (16 Marks)				
1.	Verify Green's theorem for $\int_C (3x - 8y^2)dx + (4y - 6xy)dy$, where C is the boundary of the region given by $x = 0,\ y = 0,\ x + y = 1$.	[BL4]	[CO1]	[16]
2.	Verify Green's theorem for $\int_C (xy + y^2)dx + x^2 dy$, where C is the closed region bounded by $y = x$, $y = x^2$.	[BL4]	[CO1]	[16]
3.	Evaluate $\int_C (y - \sin x)dx + \cos x\, dy$ by using Greens theorem where C is the triangle formed by the lines $y = 0$, $x = \frac{\pi}{2}$ and $y = \frac{2x}{\pi}$.	[BL5]	[CO1]	[16]
4.	Verify Gauss divergence theorem for $\vec{F} = 4xz\,\vec{i} - y^2\vec{j} + yz\vec{k}$ over the cube bounded by $x = 0,\ x = 1,\ y = 0,\ y = 1,\ z = 0,\ z = 1$.	[BL4]	[CO1]	[16]
5.	Verify Gauss divergence theorem for $\vec{F} = (x^2 - yz)\vec{i} + (y^2 - zx)\vec{j} + (z^2 - xy)\vec{k}$ taken over the rectangular parallelepiped bounded by $x = 0,\ x = a,\ y = 0,\ y = b,\ z = 0,\ z = c$	[BL4]	[CO1]	[16]
6.	Verify Gauss divergence theorem for $\vec{F} = x^2\vec{i} + y^2\vec{j} + z^2\vec{k}$ taken over the cube bounded by the planes x=0, x=a, y=0, y=b, z=0, z=c.	[BL4]	[CO1]	[16]
7.	Verify Stoke's theorem, $\vec{F} = (x^2 + y^2)\vec{i} - 2xy\vec{j}$, taken around the rectangular region bounded by the lines $x = \pm a,\ y = 0,\ y = b$	[BL4]	[CO1]	[16]

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8.	Verify Stoke's theorem for $\vec{F}=(y-z)\vec{i}+(yz)\vec{j}-xz\vec{k}$ where Sis the surface bounded by the planes $x=0,\ x=1,\ y=0,\ y=1,\ z=0,\ z=1$ not included in the xoy plane (above XOY Plane).	[BL4]	[CO1]	[16]
9.	(i) Prove that $\vec{F}=(6xy+z^3)\vec{i}+(3x^2-z)\vec{j}+(3xz^2-y)\vec{k}$ is irrotational vector and find the scalar potential such that $\vec{F}=\nabla\varphi$.	[BL5]	[CO1]	[8]
	(ii) Find the angle between the surfaces $z=x^2+y^2-3$ and $x^2+y^2+z^2=9$ at $(2,-1,2)$.	[BL4]		[8]
10.	Determine a and b such that the surfaces $ax^2-byz=(a+2)x$ and $4x^2y+z^3=4$ cut orthogonally at (1, -1, 2).	[BL5]	[CO1]	[16]

UNIT- II –ANALYTIC FUNCTIONS				
	PART A (2 Marks)	**Bloom's Level**	**Course Outcome**	**Marks Allotted**
1.	State the necessary and sufficient conditions for f (z) to be analytic.	[BL1]	[CO2]	[2]
2.	Verify whether $f(z)=\overline{z}$ is analytic function or not.	[BL2]	[CO2]	[2]
3.	Show that f (z) = $\lvert z\rvert^2$ is differentiable at z=0 but not analytic.	[BL2]	[CO2]	[2]
4.	Check for the analyticity of $logz$	[BL3]	[CO2]	[2]
5.	State any two properties of analytic functions.	[BL1]	[CO2]	[2]
6.	Show that xy^2 cannot be the real part of an analytic function.	[BL2]	[CO2]	[2]
7.	Find the value of *m* if $u=2x^2-my^2+3x$ is harmonic.	[BL3]	[CO2]	[2]
8.	Find the image of the circle $\lvert z\rvert=3$ under the transformation $w=2z$.	[BL4]	[CO2]	[2]
9.	Find the invariant points of the bilinear transformation $\frac{z-1}{z+1}$	[BL2]	[CO2]	[2]
10.	Determine the critical points of the transformation $w^2=(z-\alpha)(z-\beta)$.	[BL3]	[CO2]	[2]

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Descriptive Questions (16 Marks)				
1.	(i) If f (z) is a regular function of z, prove that $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\lvert f(z)\rvert^2 = 4\lvert f'(z)\rvert^2$. (ii) Find the analytic function f(z) whose real part is $\frac{\sin\ 2x}{\cos h\ 2y + \cos 2x}$	[BL4]	[CO2]	[8] [8]
2.	(i) If f (z) is a regular function of z, prove that $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\lvert f(z)\rvert = 0$ (ii) Find the analytic function $f(z) = u + iv$ if $u - v = e^x(cosy - siny)$	[BL4]	[CO2]	[8] [8]
3.	Show that the function $u = \frac{1}{2}\log(x^2 + y^2)$ is harmonic and determine its conjugate harmonic. Also find $f(z)$.	[BL5]	[CO2]	[16]
4.	(i) Find the analytic function f(z)=u+iv whose imaginary part is $e^{-x}(xcosy + ysiny)$. (ii) Prove that the real and imaginary parts of an analytic function satisfy the Laplace equation in two dimension $\nabla^2 u = 0$ & $\nabla^2 v = 0$.	[BL5]	[CO2]	[8] [8]
5.	(i) Prove that $u = x^2 - y^2$ and $v = \frac{-y}{x^2+y^2}$ both satisfy the Laplace equation but u+iv is not analytic. (ii) Find the bilinear transformation which maps the points $z = -1, 0, 1$ onto the points $w = -1, -i, 1$.	[BL5]	[CO2]	[8] [8]
6.	Show that the transformation $w = \frac{1}{z}$ transforms all circles and straight lines in the z-plane into circles or straight lines in the w-plane.	[BL5]	[CO2]	[16]
7.	Find the image of the infinite strips (i) $\frac{1}{4} < y < \frac{1}{2}$ (ii) $0 < y < \frac{1}{2}$, under the transformation $w = \frac{1}{z}$.	[BL4]	[CO2]	[16]
8.	(i) Find the image of $\lvert z - 2i\rvert = 2$ under the transformation $w = \frac{1}{z}$. (ii) Find the bilinear transformation which maps the points $z = 1, i, -1$ onto the points $w = i, 0, -i$.	[BL4]	[CO2]	[8] [8]

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9.	(i) Find the image of $1 < x < 2$ under the transformation $w = \frac{1}{z}$. (ii) Find the bilinear transformation that maps the points z =1,i, -1 onto the points w = 0,1,∞.	[BL5] [BL4]	[CO2]	[8] [8]
10.	Find the bilinear transformation that maps the points z =0,-1,i into the points w= i,0,∞ respectively. Also find the image of the unit circle $\lvert z \rvert = 1$.	[BL5]	[CO2]	[16]

UNIT- III –COMPLEX INTEGRATION				
	PART A (2 Marks)	**Bloom's Level**	**Course Outcome**	**Marks Allotted**
1.	State Cauchy's Integral theorem.	[BL1]	[CO3]	[2]
2.	Evaluate $\int_C \frac{3z^2+7z+1}{z+1}$dz, where C is $\lvert z\rvert = \frac{1}{2}$.	[BL4]	[CO3]	[2]
3.	Evaluate $\int_C \frac{z}{(z-2)} dz$ where C is the unit circle$\lvert z\rvert = 3$.	[BL4]	[CO3]	[2]
4.	Expand f(z) $= e^z$ as a Taylor series about the point $z = 0$.	[BL3]	[CO3]	[2]
5.	Obtain the Taylor series expansion of $log\ (1+z)$ about $z = 0$.	[BL3]	[CO3]	[2]
6.	State Cauchy's Residue theorem.	[BL1]	[CO3]	[2]
7.	Find the residue of $\frac{1-e^{2z}}{z^4}$ at z=0	[BL3]	[CO3]	[2]
8.	Define singular points.	[BL1]	[CO3]	[2]
9.	Classify the singularities for the function $f(z) = \frac{sinz-z}{z^3}$ at z=0.	[BL2]	[CO3]	[2]
10.	Define essential singularities and give an example.	[BL1]	[CO3]	[2]
	Descriptive Questions (16 Marks)			
1.	(i) Evaluate $\int_C \frac{z+4}{z^2+2z+5}\, dz$,where C is the circle $\lvert z+1+i\rvert$=2 by Cauchy's Integral formula. (ii) Expand as a Laurent's series of the function $f(z) = \frac{z}{z^2-3z+2}$ in the region $1 < \lvert z\rvert < 2$ and $\lvert z\rvert > 2$.	[BL4]	[CO3]	[8] [8]

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2.	(i) Using Cauchy's integral formula evaluate $\int_c \frac{\sin \pi z^2 + \cos \pi z^2}{(z-2)(z-3)} dz$ where C is $\|z\| = 4$. (ii) Evaluate $\int_c \frac{z-1}{(z+1)^2(z-2)} dz$ where c is the circle $\|z-i\| = 2$, using Cauchy's Reside theorem.	[BL5]	[CO3]	[8] [8]
3.	(i) Find the Laurent's series expansion of the function $f(z) = \frac{7z-2}{z(z-2)(z+1)}$ valid in the region $1 < \|z+1\| < 3$. (ii) Evaluate $\int_C \frac{zdz}{(z-1)(z-2)^2}$ where C is $\|z-2\| = \frac{1}{2}$ using Cauchy's integral formula.	[BL5]	[CO3]	[8] [8]
4.	Find the Laurent's series expansion of the function $f(z) = \frac{z^2-1}{z^2+5z+6}$ valid in the regions a) $2 < \|z\| < 3$ b) $\|z\| < 2$ c) $\|z\| > 3$	[BL5]	[CO3]	[16]
5.	Using contour integration, evaluate $\int_0^{2\pi} \frac{d\theta}{13+5\sin\theta}$.	[BL5]	[CO3]	[16]
6.	Evaluate $\int_0^{2\pi} \frac{d\theta}{a+b\cos\theta}$, $a > b$ by using contour integration.	[BL5]	[CO3]	[16]
7.	Evaluate $\int_0^{2\pi} \frac{d\theta}{(1-2a\cos\theta+a^2)}, \|a\| < 1$ using contour integration.	[BL5]	[CO3]	[16]
8.	Evaluate $\int_{-\infty}^{\infty} \frac{x^2}{(x^2+a^2)(x^2+b^2)} dx$ a>0, b>0 using contour integration.	[BL5]	[CO3]	[16]
9.	Evaluate $\int_{-\infty}^{\infty} \frac{x^2-x-2}{x^4+10x+9} dx$, by using contour integration.	[BL5]	[CO3]	[16]
10.	Evaluate $\int_0^{\infty} \frac{1}{(1+x^2)^2} dx$, by using contour integration.	[BL5]	[CO3]	[16]

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UNIT- IV -FOURIER TRANSFORMS				
PART A (2 Marks)		**Bloom's Level**	**Course Outcome**	**Marks Allotted**
1.	State Fourier integral theorem.	[BL1]	[CO4]	[2]
2.	Write the Fourier transform pair.	[BL1]	[CO4]	[2]
3.	State Parseval's identity on Fourier transform.	[BL1]	[CO4]	[2]
4.	Write down the Fourier sine transform pair.	[BL1]	[CO4]	[2]
5.	Write down the Fourier cosine transform pair.	[BL1]	[CO4]	[2]
6.	Find the Fourier sine transform of $f(x) = e^{-ax}$ where a>0	[BL2]	[CO4]	[2]
7.	Find the Fourier cosine transform of $f(x) = e^{-ax}$ where a>0	[BL2]	[CO4]	[2]
8.	Find the Fourier sine transform of $\frac{1}{x}$.	[BL2]	[CO4]	[2]
9.	Does Fourier Sine transform of $f(x) = k \quad 0 \leq x \leq \infty$ exist? Justify your answer.	[BL3]	[CO4]	[2]
10.	Define self-reciprocal with respect to Fourier transform.	[BL1]	[CO4]	[2]
Descriptive Questions (16 Marks)				
1.	Find the Fourier transform of $f(x) = \begin{cases} a - \lvert x\rvert \ ; for \ \lvert x\rvert < a \\ 0 \ ; \ for \ \lvert x\rvert > a > 0 \end{cases}$. Hence show that $\int_0^\infty \left(\frac{sint}{t}\right)^2 dt = \frac{\pi}{2}$ and $\int_0^\infty \left(\frac{sint}{t}\right)^4 dt = \frac{\pi}{3}$. pg.no.4.41	[BL5]	[CO4]	[16]
2.	Find the Fourier transform of $(x) = \begin{cases} a^2 - x^2 \ ; for \ \lvert x\rvert < a \\ 0 \quad ; for \ \lvert x\rvert > a > 0 \end{cases}$. Hence deduce that $\int_0^\infty \left(\frac{sint - tcost}{t^3}\right) dt = \frac{\pi}{4}$ and $\int_0^\infty \left(\frac{sint - tcost}{t^3}\right)^2 dt = \frac{\pi}{15}$. pg.no.4.52	[BL5]	[CO4]	[16]
3.	Find the Fourier transform of $f(x) = \begin{cases} 1 \ ; for \ \lvert x\rvert < a \\ 0 \ ; for \ \lvert x\rvert > a \end{cases}$ and hence find the value of $\int_0^\infty \left(\frac{sinx}{x}\right) dx$ and $\int_0^\infty \left(\frac{sint}{t}\right)^2 dt$.	[BL4]	[CO4]	[16]
4.	Find the Fourier transform of $f(x) = \begin{cases} 1 - x^2 \ ; for \ \lvert x\rvert < 1 \\ 0 \quad ; for \ \lvert x\rvert \geq 1 \end{cases}$. Hence prove that $\int_0^\infty \left(\frac{sins - scos\, s}{s^3}\right) cos\left(\frac{s}{2}\right) ds = \frac{3\pi}{16}$ and $\int_0^\infty \left(\frac{sins - scos\, s}{s^3}\right)^2 ds = \frac{\pi}{15}$.	[BL4]	[CO4]	[16]

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5.	Show that $e^{\frac{-x^2}{2}}$ is a self-reciprocal with respect to Fourier transform.	[BL5]	[CO4]	[16]
6.	Find the Fourier sine transform of $f(x) = e^{-ax}$ where a>0 and hence deduce that $\int_0^{\infty} \frac{s \, sinsx}{a^2+s^2} \, ds = \frac{\pi}{2} e^{-ax}$.	[BL4]	[CO4]	[16]
7.	Find the Fourier cosine transform of $f(x) = e^{-ax}$ where a>0 and hence deduce that $\int_0^{\infty} \frac{cosxt}{a^2+t^2} dt = \frac{\pi}{2a} e^{-a\|x\|}$	[BL4]	[CO4]	[16]
8.	Find the Fourier sine transform and Fourier cosine transforms of xe^{-ax}.	[BL4]	[CO4]	[16]
9.	Using Parseval's identity, evaluate the following integrals (i) $\int_0^{\infty} \frac{dx}{(x^2+a^2)(x^2+b^2)}$ (ii) $\int_0^{\infty} \frac{x^2 \, dx}{(x^2+a^2)(x^2+b^2)}$	[BL5]	[CO4]	[16]
10.	Using Parseval's identity, evaluate the following integrals (i) $\int_0^{\infty} \frac{dx}{(x^2+a^2)^2}$ (ii) $\int_0^{\infty} \frac{x^2 dx}{(x^2+a^2)^2}$	[BL5]	[CO4]	[16]

UNIT- V -LAPLACE TRANSFORM				
	PART A (2 Marks)	**Bloom's Level**	**Course Outcome**	**Marks Allotted**
1.	State the conditions under which the Laplace transform of $f(t)$ exist.	[BL1]	[CO5]	[2]
2.	State and prove first shifting theorem.	[BL1]	[CO5]	[2]
3.	State and prove change of scale property.	[BL1]	[CO5]	[2]
4.	Is the linearity property applicable to $L\left(\frac{1-\cos t}{t}\right)$	[BL2]	[CO5]	[2]
5.	Does $L\left(\frac{\cos at}{t}\right)$ exist?	[BL3]	[CO5]	[2]
6.	Find the $L^{-1}\left[\frac{1}{(s+1)^2+1}\right]$	[BL2]	[CO5]	[2]

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7.	Find the inverse Laplace transform of $\log\left(\frac{s+1}{s-1}\right)$	[BL3]	[CO5]	[2]
8.	Find the Laplace transform of unit step function.	[BL2]	[CO5]	[2]
9.	State Initial and Final value theorems.	[BL3]	[CO5]	[2]
10.	State convolution theorem.	[BL1]	[CO5]	[2]
	Descriptive Questions (16 Marks)			
1.	(i) Find the Laplace transform of the triangular wave function $f(t)=\begin{cases} t & 0\le t\le a \\ 2a-t & a\le t\le 2a\end{cases}$ with f(t) = f(t + 2a) ex.no.5.8.4 (ii) Find $L[t^2e^{-t}cost]$ eg.no.5.7.12 pg.no.5.83	[BL4]	[CO5]	[8] [8]
2.	(i) Find the Laplace transform of the function $f(t)$ with period $\frac{2\pi}{\omega}$ for $f(t)=\begin{cases} sin\omega t \ for \ 0<t<\frac{\pi}{\omega} \\ 0 \ for \frac{\pi}{\omega}<t<\frac{2\pi}{\omega}\end{cases}$ (ii) Find $L^{-1}\left(\frac{s}{(s^2+a^2)^2}\right)$ using convolution theorem.	[BL4]	[CO5]	[8] [8]
3.	(i) Find the Laplace transform of the square wave function $f(t)=\begin{cases} E & 0\le t\le \frac{a}{2} \\ -E & \frac{a}{2}\le t\le a\end{cases}$ with f(t) = f(t + a). (ii) Find $L^{-1}\left(\frac{s}{(s^2+a^2)(s^2+b^2)}\right)$ using convolution theorem.	[BL4]	[CO5]	[8] [8]
4.	(i) Find the Laplace transform of the square wave function f(t) given by $f(t)=\begin{cases} K, & 0\le t\le a \\ -K, & a\le t\le 2a\end{cases}$ and $f(t+2a)=f(t)$ (ii) Find $L\left(\frac{\cos at-\cos bt}{t}\right)$	[BL5] [BL4]	[CO5]	[8] [8]
5.	Using convolution theorem, find $L^{-1}\left[\frac{s^2}{(s^2+a^2)(s^2+b^2)}\right]$	[BL5]	[CO5]	[16]
6.	(i) Verify Initial and Final Value theorem for $f(t)=1+e^{-t}(sint+cost)$.	[BL4]	[CO5]	[8]

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	(ii) Find $L\left(\frac{e^{-at}-e^{-bt}}{t}\right)$			[8]
7.	Using Laplace transform, solve $y''-3y'+2y=1$ given that $y(0)=1, y'(0)=1$.	[BL5]	[CO5]	[16]
8.	Using Laplace transform solve $y''-3y'+2y=e^{3t}$ given that $y(0)=1,\ y'(0)=0$.	[BL5]	[CO5]	[16]
9.	Using Laplace transform, solve $(D^2+9)y=cos2t$, given that if $y(0)=1, y\left(\frac{\pi}{2}\right)=-1$	[BL5]	[CO5]	[16]
10.	Using Laplace transform, solve $\frac{d^2y}{dt^2}+\frac{dy}{dt}=t^2+2t$ given that $y=4\ and\ y'=-2$ when $t=0$	[BL5]	[CO5]	[16]

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