INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal- 500 043, Hyderabad,Telengana

ELECTRONICS AND COMMUNICATION ENGINEERING
QUESTION BANK

Course Title	**COMPLEX ANALYSIS AND SPECIAL FUNCTIONS**				
Course Code	AHSD12				
Program	B.Tech				
Semester	III	ECE			
Course Type	Foundation				
Regulation	IARE - BT 23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. A. Parandhama, Associate Professor				

COURSE OBJECTIVES:
The students will try to learn:

I	The applications of complex variable in two dimensional complex potential theories.
II	The fundamental calculus theorems and criteria for the independent path on contour integral used in problems of engineering.
III	The concepts of special functions and its application for solving the partial differential equations in physics and engineering.
IV	The Mathematics of combinatorial enumeration by using generating functions and complex analysis for understanding the numerical growth rates.

COURSE OUTCOMES:
After successful completion of the course, students should be able to:

CO 1	**Identify** the fundamental concepts of analyticity and differentiability for finding complex conjugates of complex transformations.	Understand
CO 2	**Apply** integral theorems of complex analysis and its consequences for the analytic function with derivatives of all orders in the simple connected region.	Apply

CO 3	**Extend** the Taylor and Laurent series for expressing the function in terms of complex power series.	Apply
CO 4	**Apply** Residue theorem for computing definite integrals by using the singularities and poles of real and complex analytic functions over closed curves.	Apply
CO 5	**Determine** the characteristics of special functions for obtaining the proper and improper integrals for obtaining the proper and improper integrals.	Apply
CO 6	**Apply** the role of Bessel functions in the process of obtaining the series solutions for second order differential equation	Apply

QUESTION BANK:

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		MODULE I		
		COMPLEX ANALYSIS AND SPECIAL FUNCTIONS		
		PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS		
1	Construct the analytic function $f(z)$ in terms of z if $f(z)$ is an analytic function of z such $u+v=\frac{\sin 2x}{\cos h2y-\cos 2x}$	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions	CO1
2	Show that if $u=x^2-y^2$, $v=-\frac{y}{x^2+y^2}$, both u and v satisfy Laplace's equation, but $u+iv$ is not a regular (analytic) function of z.	Understand	Learner to recall condition for function to be Laplace equations and understand the concept of regular functions.	CO1
3	Construct the analytic function$f(z)$ given $u-v=\frac{(cosx+sinx-e^{(-y)})}{2cosx-e^y-e^{-y}}$ and $f(z)$ is subjected to the condition $f(\frac{\pi}{2})=0$	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1
4	Construct the analytic function f (z) whose real part of it is $u=e^x[(x^2-y^2)cosy-2xysiny)]$.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1
5	Show that $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\|f(z)\|=0$ where $w=f(z)$ is an analytic function.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1

6	Show that the function defined by $\begin{cases} \frac{xy^2(x+iy)}{x^2+y^4}, z \neq 0 \\ 0, z = 0 \end{cases}$ is not analytic even though Cauchy Riemann equations are satisfied at origin.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of regular functions through Cauchy-Riemann equations.	CO1
7	Show that the function defined by $\begin{cases} \frac{2xy(x+iy)}{x^2+y^2}, z \neq 0 \\ 0, z = 0 \end{cases}$ is continuous at origin,CR equations also satisfied at origin, yet derivative doesnot exist at origin.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of regular functions through Cauchy-Riemann equations.	CO1
8	Show that the function $f(z) = \sqrt{\lvert xy \rvert}$ is not analytic at the origin although Cauchy–Riemann equations are satisfied at the origin.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1
9	Utilize the complex potential for an electric field $\omega = \phi + i\varphi$ where $\varphi = \mathrm{x}^2 - \mathrm{y}^2 + \frac{\mathrm{x}}{\mathrm{x}^2+\mathrm{y}^2}$ and determine the function $\emptyset$.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1
10	In a two-dimensional flow of a fluid, the velocity potential $\phi = x^2 - y^2$. Find the stream function ψ.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1
		PART-B LONG ANSWER QUESTIONS		
1	Find constants a , b such that the following function is analytic, Where f(z) = 3x-y+5 +i(ax+by-3)	Understand	Learner to recall cartesian form of complex function and understand Cauchy's Riemann equations in Cartesian form and apply them to find Cauchy Riemann conditions	CO1
2	Show that the real part of an analytic function $f(z)$ where $u = log\lvert z\rvert^2$ is a harmonic function. If so find the analytic function by Milne Thompson method.	Understand	Learners recall Cauchy-Riemann equations and understand Milne Thompson's method of finding analytic functions.	CO1

3	Use Milne Thompson's method to find the imaginary part of an analytic function $f(z)$ whose real part of an analytic function is $e^{2x}(xcos2y - ysin2y)$	Understand	Learners recall the Cauchy-Riemann equations and understanding the method to find imaginary part.	CO 1
4	Show that $\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right) \lvert Real f\,(z)\rvert^2 = 2\lvert f'\,(z)\rvert^2$ where $w = f(z)$ is an analytic function.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions	CO 1
5	Find an analytic function f(z) whose real part of an analytic function is $u = \frac{\sin 2x}{\cos h2y - \cos 2x}$ by Milne-Thompson method.	Remember	-	CO1
6	Show that $$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right) \lvert f\,(z)\rvert^2 = 4\left\lvert f'\,(z)\right\rvert^2$$ If $f(z)$ is a regular function of z	Understand	Learner to recall Cauchy-Riemann equations and understand Milne Thompson's method.	CO1
7	Show that the function defined by $\begin{cases} \frac{x^2y}{x^4+y^2}, z \neq 0 \\ 0, z = 0 \end{cases}$ is not conrinuous at origin.	Understand	Learner to recall limits and continuous concept of regular functions through at origin.	CO1
8	Show that real part $u = x^3 - 3xy^2$ of an analytic function $f(z)$ is harmonic. Hence find the conjugate harmonic function and the analytic function.	Understand	Learner to recall the concept of a harmonic function and understand the concept of finding harmonic conjugate.	CO1
9	Find whether the following function is analytic or not, Where ,f(z) = Sinx Coshy + i Cosx Sinhy .	Understand	Learner to recall cartesian form of complex function and understand Cauchy's Riemann equations in Cartesian form and apply them to find Cauchy Riemann conditions	CO1
10	Show that an analytic function $f(z)$ with constant imaginary part is always constant.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1

11	Find the analytic function $f(z)$ whose imaginary part of the analytic function is $v = e^x(xsiny + ycosy)$.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of regular functions through Cauchy-Riemann equations.	CO1
12	Show that the real part of an analytic function $f(z)$ where $u = 2log(x^2 + y^2)$ is harmonic.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of regular functions through Cauchy-Riemann equations.	CO1
13	Show that the function$f(z) = exp(z)$ is continuous at all points of z. Find $f'(z)$.	Understand	Learner to recall the concept of continuous function and understand the prove for differentiability	CO 1
14	List all the values of k such that$f(z) = e^x(cosky + isinky)$ is an analytic function	Remember	Learner to recall Cauchy-Riemann equations and understand the concept of regular functions through Cauchy-Riemann equations.	CO1
15	Show that an analytic function $f(z)$ with constant real part is always constant.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO1
16	Show that an analytic function$f(z)$ with constant modulus is always constant.	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of regular functions through Cauchy-Riemann equations.	CO1
17	Show that u and v are harmonic functions if u and v is conjugate harmonic functions.	Understand	Learner to recall the concept of a harmonic function and understand the concept of finding harmonic conjugate.	CO 1
18	If $w = \phi + i\,\psi$ represents the complex potential for an electric field and $\psi = 3x^2y - y^3$. Find ϕ	Understand	Learner to recall Cauchy-Riemann equations and understand the concept of analytic functions.	CO 1
19	Find the analytic function $f(z)$ whose imaginary part of the analytic function is $v = e^x(xcosy - ysiny)$ by Milne - Thomson method	Understand	Learner to recall Cauchy-Riemann equations and understanding Milne Thompson's method.	CO 1

20	If $u-v=(x-y)\left(x^2+4\,x\,y+y^2\right)$ and $f\,(z)=u+i\,v$ is an analytic function of $z=x+i\,y$, find $f(z)$ in terms of z by Milne - Thomson method	Understand	Learner to recall Cauchy-Riemann equations and understanding Milne Thompson's method.	CO 1
PART-C SHORT ANSWER QUESTIONS				
1	Define the term Analyticity of a complex variable function $f(z)$.	Remember	-	CO1
2	Define the term Continuity of a complex variable function$f(z)$.	Remember	-	CO1
3	Define the term Differentiability of a complex variable function $f(z)$.	Remember	-	CO1
4	Show that complex variable function $f(z)=z^3$ to analyticity for all values of z in Cartesian form.	Understand	Learner to recall the concept of a harmonic function and Understand how to prove that it is part of analytic function	CO1
5	Show that the function $v=x^3y-xy^3+xy+x+y$ can be imaginary part of an analytic function $f(z)$ where $z=x+iy$.	Understand	Learner to recall the concept of a harmonic function and Understand how to prove that it is part of analytic function	CO1
6	Show that the function $f(z)=\|z\|^2$ does not satisfy Cauchy-Riemann equations in Cartesian form.	Understand	Learner to recall the Cauchy-Riemann equations and understand how to prove the analytic nature	CO1
7	Show that the complex variable function $f(z)=\frac{x-iy}{x^2+y^2}$ for analyticity in Cartesian form.	Understand	Learner to recall the Cauchy-Riemann equations and understand how to prove the analytic nature	CO1
8	Show that the function $f\,(z)\,=sinxsiny{-}icosxcosy$ is not analytic function.	Understand	Learner to recall the Cauchy-Riemann equations and understand how to prove the analytic nature	CO1
9	Find the value of k such that $f(x,y)=x^3+3kxy^2$ may be harmonic function.	Remember	-	CO1

10	Find the analytic function $f(z)$ whose real part of the analytic function is $u = x^2 - y^2 - x$	Remember	-	CO1
11	Find the analytic function $f(z)$ whose imaginary part of the analytic function is $v = e^x(xsiny + ycosy)$.	Remember	-	CO1
12	Show that the real part of an analytic function $f(z)$ where $u = 2log(x^2 + y^2)$ is harmonic.	Remember	-	CO1
13	Show that the function$f(z) = \|z\|^2$ is continuous at all points of z but not differentiable at any .	Understand	Learner to recall the concept of continuous function and understand the prove for differentiability	CO 1
14	Show that the real part of an anlaytic function $f(z)$ where$f(z) = e^x(cosy - isiny)$ is harmonic function.	Remember	-	CO1
15	Find the values of a, b, c such that $f(z) = x + ay - i(ax + by)$is differentiable function at every point.	Apply	Learner to recall the concept of continuous function and understand the prove for differentiability	CO 1
16	Show that every differentiable function is continuous or not. Give a valid example.	Understand	Learner to recall the concept of continuous function and understand the concept of differentiability with illustration.	CO1
17	State whether $sin\,(x - iy)$ is analytic or not ?.	Remember	-	CO 1
18	Show that $w = f\,(z) = \log z$ is analytic everywhere in the complex plane except at the origin and that its derivative is $1/z$	Remember	Learner to recall the concept of differentiability and continuous function and understand the prove for differentiability	CO 1
19	Show that the function $u = \frac{1}{2}\log\left(x^2 + y^2\right)$ is harmonic and determine its conjugate.	Apply	Learner to recall the concept of continuous function and understand the prove for differentiability	CO 1

20	Find the analytic function whose real part is $\frac{x}{x^2+y^2}$	Understand	Learner to recall the C-R equations and solve the problem for differentiability.	CO 1
MODULE II				
COMPLEX INTEGRATION				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Solve the value of line integral to $\int_c \frac{z}{(z-1)(z-2)^2}dz$ where C is the circle $\lvert z-2\rvert = 1/2$ using Cauchy's integral formula.	Apply	Learner to recall the method of finding line integral in real analysis understand the variable value along the line and apply integral concepts.	CO 2
2	Solve the value of line integral to $\int_c \frac{z^4}{(z+1)(z-i)^2}dz$ where C is the ellipse $9x^2+4y^2=36$ using Cauchy's integral formula.	Apply	Learner to recall the method of finding line integral in real analysis understand the variable value along the line and apply integral concepts.	CO 2
3	Compare Cauchy's integral formula with line integral to $\int_c \frac{z^4-3z^2+6}{(z+i)^3}dz$ where C is the circle $\lvert z\rvert = 2$ and find the integral.	Apply	Learner to recall Cauchy general integral formula and understand how to find solutions by comparison.	CO 2
4	Compare Cauchy's integral formula with line integral to $\int_c \frac{z^2-2z-2}{(z^2+1)^2}dz$ where C is the circle $\lvert z-i\rvert = 1/2$ and find integral.	Apply	Learner to recall Cauchy general integral formula and understand how to find solutions by comparison.	CO 2
5	Solve the value of line integral to $\int_c \frac{e^z}{(z^2+\pi^2)^2}dz$ where C is $\lvert z\rvert = 4$using Cauchy's integral formula.	Apply	Learner to recall the method of finding line integral in real analysis and understand the variable value along the line and apply integral concepts.	CO 2
6	Solve the value of line integral to $\int_c \frac{\cos \pi z}{(z-1)(z-2)^3}dz$ where C is the circle $\lvert z\rvert = 3$ using Cauchy's integral formula.	Apply	Learner to recall the method of finding line integral in real analysis and understand the variable value along the line and apply integral concepts.	CO 2

7	Solve the value of line integral to $\int_0^{1+i}(x-y+ix^2)dz$ i) Along the straight line from z = 0 to z = 1+i. ii) Along the real axis from z = 0 to z = 1 and then along a line parallel to imaginary axis from z = 1 to z = 1+i iii) Along the imaginary axis from z = 0 to z = i and then along a line parallel to real axis z = i to z = 1+ i	Apply	Learner to recall the method of finding line integral in real analysis understand the variable value along the line and apply integral concepts.	CO2
8	Make use of the vertices $-1+i, -1-i, 1+i, 1-i$ and verify Cauchy's theorem for the integral of $3z^2+iz-4$ taken over the boundary of the square .	Apply	Learner to recall the method of finding line integral in real analysis understand the variable value along the line and apply integral concepts.	CO2
9	Solve the value of line integral to $\int_0^{1+i}(y-x+i3x^2)dz$ along the imaginary axis from z = 0 to z = i and then along a line parallel to real axis z = i to z = 1+ i	Apply	Learner to recall the method of finding line integral in real analysis and understand the variable value along the line and apply integral concepts	CO 2
10	Solve the value of line integral to $\int_C \left(y^2+2xy\right)dx+\left(y^2-2xy\right)dy$ where C is the boundary of the region$y = x^2 and x = y^2$.	Apply	Learner to recall Cauchy's general integral formula and understand how to find solutions by comparison.	CO 2
PART-B LONG ANSWER QUESTIONS				
1	Utilize Cauchy's integral formula and find the value of $\int_c \frac{z^3-\sin 3z}{(z-\pi/2)^3}$dz where c is the circle $\lvert z\rvert$ =2.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2

2	Make use of vertices $-1, 1, 1+i, -1+i$ and verify Cauchy's theorem for the integral of z^3 taken over the boundary of the rectangle formed.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
3	Solve the value of line integral to $\int_c \frac{e^{2z}}{(z-1)(z-2)}$ dz where c is the circle $\lvert z\rvert$ =3 using Cauchy's integral formula.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
4	Compare Cauchy's integral formula with line integral to $\int_c \frac{z^3 e^{-z}}{(z-1)^3}$ dz where c is $\lvert z-1\rvert = \frac{1}{2}$ and find the value of integral.	Understand	Learner to recall the Cauchy integral formula and understand how to find solutions by comparison.	CO 2
5	Solve the value of line integral to $$\int_c \frac{5z^2-3z+2}{(z-1)^3}dz$$ where c is any simple closed curve enclosing $\lvert z\rvert$=1 using Cauchy's integral formula.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
6	Solve the value of line integral to $$\int_{z=0}^{z=1+i} [x^2+2xy+i\left(y^2-x\right)]dz$$ along the curve $y=x^2$.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
7	Solve the integral $\int_c (3z^2+2z-4)dz$ around the square with vertices at (0,0), (1,0), (1,1) and (0,1).	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2

8	Utilize the function $f(z) = 5\sin 2z$ and verify Cauchy's theorem for c is the square with vertices at $1+i, 1-i$ and $-1+i, -1-i$.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
9	Compare Cauchy's integral formula with line integral to $$\int\limits_C \frac{(sin^2 z)}{\left(z-\frac{\pi}{6}\right)^3} dz$$ around the unit circle and find the integral.	Apply	Learner to recall Cauchy's integral formula and understand how to find a solution by comparison.	CO 2
10	Solve the value of to $\int\limits_c \frac{e^{2z}}{(z+1)^4} dz$ where c is $\lvert z-1 \rvert = 3$ using Cauchy's general integral formulae.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
11	Make use of Cauchy's integral formula and evaluate $\int\limits_c \frac{z+1}{z^2+2z+4} dz$ Where $c : \lvert z+1+i \rvert = 2$.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
12	Solve the value of line integral to $$\int\limits_C \left(y^2+z^2\right) dx + \left(z^2+x^2\right) dy + \left(x^2+y^2\right) dz$$ from $(0,0,0)$ to $(1,1,1)$ where C is the curve $x=t, y=t^2, z=t^3$ in the parametric form.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
13	Compare Cauchy general integral formula with $\int\limits_c \frac{e^z}{z^2(z+1)^3} dz$ and estimate the value of integral with $C : \lvert z \rvert = 2$.	Understand	Learner to recall the Cauchy integral formula and understand how to find solutions by comparison.	CO 2
14	Find the value of the line integral to $\int\limits_0^{3+i} z^2 dz$ along the straight line y = x/3	Understand	Learner to recall the Cauchy integral formula and understand how to find solutions by comparison.	CO 2

15	Solve the value of line integral to $\int_{0}^{3+i} z^2 dz$ along the parabola $x = 3y^2$.	Apply	Learner to recall Cauchy integral formula and understand how to find solution by comparison by applying integral concepts.	CO 2
16	Compare Cauchy general integral formula with $\int_C \frac{1}{e^z(z-1)^3} dz$ and estimate the value of integral with C: $\lvert z \rvert = 2$.	Apply	learner to recall Cauchy general integral formula and understand how to find a solution by comparison.	CO 2
17	Compare Cauchy general integral formula with $\int_C \frac{e^z \sin 2z - 1}{z^2(z+2)^2} dz$ and estimate the value of integral with $C : \lvert z \rvert = \frac{1}{2}$. Solve the value of where $C : \lvert z \rvert = 1/2$ using Cauchy integral formulae.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
18	Compare Cauchy's integral formula with line integral to $\int_c \left[\frac{e^z}{z^3} + \frac{z^4}{(z-i)^2}\right] dz$, $C : \lvert z \rvert = 2$ and find the integral.	Apply	learner to recall Cauchy general integral formula and understand how to find a solution by comparison.	CO 2
19	Find the value of the line integral to $\int_C (z^2 + 3z) dz$ along the straight line from $(2, 0) to (2, 2)$ and then from $(2, 2) to (0, 2)$.	Remember	-	CO 2
20	Solve the value of line integral to $\int_C \frac{\cos hz}{z^4} dz$ if C denote the boundary of a square whose sides lie along the lines $x = \pm$ 2 and $y = \pm$ 2 where C is described in positive sense.	Apply	Learner to recall Cauchy integral formula and understand how to find solutions by comparison by applying integral concepts.	CO 2
PART-C SHORT ANSWER QUESTIONS				
1	Define the Cauchy's integral formula.	Remember	-	CO 2
2	Define the Cauchy's General integral formula.	Remember		CO 2

3	Define the term Radius of convergence.	Remember	-	CO 5
4	Define the term Power series expansions of complex functions.	Remember	-	CO 2
5	Define the term Line Integral of complex variable function w = f (z).	Remember	-	CO 2
6	Define the term Contour Integration of a given curve in complex function.	Remember	-	CO 2
7	Define Cauchy's integral theorem for multiple connected regions.	Remember		CO 2
8	Find the value of $\int_0^{1+i} z^2 dz$.	Remember	-	CO 2
9	Find the value of $\int_C \frac{3z^2+7z+1}{(z+1)} dz$ with $C : \|z+i\| = 1$ by Cauchy integral formulae.	Remember	-	CO 2
10	Find the value of the line integral to $\int_0^{2+i} z^2 dz$ along the real axis to 2 and then vertically to (2+i).	Remember	-	CO 2
11	Find the value of the line integral to $\int_0^{3+i} z^2 dz$ along the straight line y = x/3	Remember	-	CO 2
12	Compare Cauchy's integral formula with $\int_C e^{-z} dz$ and find the integral $C : \|z-1\| = 1$	Understand	Learner to recall Cauchy's integral formula and understand how to find a solution by comparison.	CO 2
13	Solve line integral to $\int_0^{2+i} (x - y^2 + ix^3) dz$ along the real axis from $z = 0$ to $z = 1$.	Remember	Learner to recall the method of finding line integral in real analysis, understand the variable value along the line, and apply integral concepts.	CO 2

14	Solve the line integral $\int\limits_C \bar{z}dz$ from $z = 0$ to $2i$ and then from $2i$ to $z = 4 + 2i$.	Remember	Learner to recall the method of finding line integral in real analysis understand the variable value along the line and apply integral concepts.	CO 2
15	Find the radius of convergence of an infinite series$f(z) = sinz$.	Remember	-	CO 2
16	Find the radius of convergence of an infinite series$f(z) =\frac{1}{1-z}$	Remember	-	CO 2
17	Find the radius of convergence of an infinite series $1 + 2^2z + 3^2z^2 + 4^2z^3 + ...$	Remember	-	CO 2
18	Solve the value of line integral $\int\limits_0^{1+i} (x^2 - iy)dz$ along the path $y = x$.	Remember	Learner to recall the method of finding line integral in real analysis and understand the variable value along the line and apply integral concepts.	CO 2
19	Solve the value of $\int\limits_C \frac{1}{z-2}dz$ around the circle $\lvert z - 1\rvert = 5$ by Cauchy's integral formulae.	Remember	Learner to recall the method of finding line integral in real analysis, understand the variable value along the line, and apply integral concepts.	CO 2
20	Solve the value of $\int\limits_C \frac{1}{(z-a)}dz = 2\pi i$ around the circle $\lvert z - a\rvert = r$ by Cauchy's integral formulae. Show that by using line integral, where c is the curve.	Understand	Learner to recall the method of finding line integral in real analysis understand the variable value along the line and apply integral concepts.	C O 2
MODULE III				
POWER SERIES EXPANSION OF COMPLEX FUNCTION				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Extend the Laurent expansion of $f(z) = \frac{1}{z^2-4z+3}$ for $1 < \lvert z\rvert < 3$ (ii)$\lvert z\rvert < 1$ (iii)$\lvert z\rvert > 3$.	Apply	Learner to recall Laurent's expansion formula and understand how to residues of given analytic function.	CO3

2	Extend the Laurent expansion $f(z)$= $\frac{(z-2)(z+2)}{(z+1)(z+4)}$ in the region where (i)$\|z\| < 1$ (ii)$1 < \|z\| < 4$.	Apply	Learner to recall Laurent's expansion formula and understand how to residues of given analytic function.	CO3
3	Extend $\frac{1}{z^2(z-3)^2}$ as Laurent's series in the region (i)$\|z\| < 1$ (ii)$\|z\| > 3$.	Apply	Learner to recall Laurent's expansion formula and understand how to residues of given analytic function.	CO3
4	Extend $f(z) = \frac{2}{(2z+1)^3}$in Taylor's series about z=0 and z=2.	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 3
5	Extend $f(z) = \frac{e^z}{z(z+1)}$ in Taylor's series about z=0 and z=2.	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 3
CIE-II				
6	Solve the integral $\oint\limits_c \frac{z-3}{(z^2+2z+5)}dz$where c is circle $\|z\| = 1$.	Apply	Learner to recall Cauchy's Residue theorem and understand where the integrand is valid over the given region and apply the formula to find integral.	CO 4
7	Solve the integral $\int\limits_0^{2\pi} \frac{d\theta}{a+b\cos\theta}$ using Residue theorem.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
8	Solve the integral $\int\limits_0^{2\pi} \frac{1}{\frac{5}{4}+\sin\theta}\,d\theta = \frac{8\pi}{3}$ using Residue theorem.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
9	Solve the integral $\int\limits_0^{2\pi} \frac{1}{(5-3\sin\theta)^2}\,d\theta = \frac{5\pi}{32}$ using Residue theorem.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4

10	Solve the integral $\int_0^{2\pi} \frac{\cos 2\theta d\theta}{5+4\cos\theta}$ using Residue theorem	Apply	Learner to recall Cauchy's Residue theorem and understand where the integrand is valid over the given region and apply the formula to find integral.	CO 4
	PART-B LONG ANSWER QUESTIONS			
1	Extend $f(z) = \frac{z-1}{z+1}$ in Taylor's series about the point $z = 1$.	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 3
2	Extend $f(z) = \frac{z-1}{z^2}$ in Taylor's series in powers of$z-1$. Also, determine the region of convergence about the point $z = 1$.	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 3
3	Extend Laurent's series expansion to the function $f(z) = \frac{z^2-4}{z^2+5z+4}$ about $1 < \lvert z \rvert < 4$	Apply	Learner to recall the Laurent's expansion formula and understanding how to residues of given analytic function	CO 3
4	Extend $f(z) = \frac{e^{2z}}{(z-1)^3}$about $z = 1$ as Laurent's series. Also, find the region of convergence about $z = 1$.	Apply	Learner to recall Laurent's expansion formula and understand how to residues of given analytic function	CO 3
5	Extend $f(z) = \frac{7z-2}{z(z+1)(z-2)}$ about $z = -1$ in the region $1 < \lvert z+1 \rvert < 3$ as Laurent's series.	Apply	Learner to recall Laurent's expansion formula and understand how to residues of given analytic function	CO 3
6	Extend $f(z) = \frac{2z^3+1}{z(z+1)}$ in Taylor's series about the point $z = 1$	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 4
7	Find Taylor's expansion of $f(z) = \frac{z+1}{(z-3)(z-4)}$ about the point $z = 2$.Determine the region of convergence.	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 4

8	Extend $f(z) = \cos z$ in Taylor's series about $z = \pi i$.	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 4
9	Extend the Laurent's series expansion of $(z) = \frac{e^z}{z(1-z)}$ about $z = 1$.	Apply	Learner to recall Laurent's expansion formula and understand how to residues of given analytic function	CO 4
10	Develop $f(z) = \frac{1+2z}{z^2+z^3}$ in a series of positive and negative powers of z.	Apply	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 4
		CIE-II		
11	Solve the value of $\int\limits_C \frac{2z-1}{z(2z+1)(z+2)} dz$ where C is the circle $\|z\| = 1$.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
12	Solve the integral $\oint\limits_C \tan z dz$ where C is circle $\|z\| = 2$.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
13	Solve the integral $\oint\limits_C \frac{dz}{(z^2+4)^2}$ where C is $\|z - i\| = 2$.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
14	Solve the integral $\oint\limits_C \frac{\coth z}{z-i} dz$ where $C$is $\|z\| = 2$.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO4

15	Solve the integral $\int\limits_C \frac{z^2\,dz}{(z^2+1)(z^2+4)}$ where C is circle $\|z\| = 4$ using Residue theorem.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
16	Solve the integral $\int\limits_0^{\pi} \frac{d\theta}{(a+b\cos\theta)}$ using Residue theorem.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
17	Solve the integral of $\oint\limits_C \frac{\sin z}{z\cos z}dz$ where C is circle $\|z\| = \pi$.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
18	Find the value of $\oint\limits_C \frac{1}{\sinh z}dz$ where C is circle $\|z\| = 4$ using Residue theorem.	Apply	-	CO 4
19	Find the value of $\oint\limits_C \frac{2e^z}{z(z-3)}dz$ where C is circle $\|z\| = 2$ using Residue theorem.	Apply	-	CO 4
20	Solve the integral $\int\limits_0^{\pi} \frac{dz}{z^2+a^2}$ using Residue theorem.	Apply	Learner to recall Cauchy's Residue theorem understand where the integrand is valid over the given region and apply the formula to find the integral.	CO 4
PART-C SHORT ANSWER QUESTIONS				
1	What is Taylor's theorem of complex power series?	Remember	—	CO 3
2	What is Laurent's theorem of complex power series?	Remember	—	CO 3
3	Define the term pole of order m of an analytic function $f(z)$.	Remember	—	CO 3
4	Define the terms Essential and Removable singularity of an analytic function $f(z)$.	Remember	—	CO 3

5	Extend f(z) $=\frac{1}{z^2}$ in powers of $z+1$ as a Taylor's series.	Understand	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 3
6	Extend $f(z) = e^z$ as Taylor's series about $z=1$.	Understand	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 3
7	Find the Poles of $\frac{1}{z^2-1}$	Remember	–	CO 3
8	Extend the Taylor series expansion of $f(z) = e^z$ about $z=1$.	Understand	Learner to recall the Taylor series expansion formula and understand how to expand the given function about the given point.	CO 3
9	Find the Poles of the function $f(z) = \frac{ze^z}{(z+2)^4(z-1)}$.	Remember	–	CO 3
10	Define the Isolated singularity of an analytic function $f(z)$.	Remember	—	CO 3
11	Define Cauchy's Residue theorem of an analytic function $f(z)$ within and on the closed curve.	Remember	-	CO 3
12	Find the Residue by Laurent's expansion to $f(z) = \frac{e^z}{(z-1)^2}$ about $z=1$.	Remember	-	CO 3
13	Compare Laurent's expansion and find the Residues of the function $f(z) = \frac{1}{(z-\sin z)}$ about $z=0$.	Understand	Learner to recall Laurent's expansion formula and understand how to residues of given analytic function.	CO 3
14	Find the Residues of the function $f(z) = \frac{z}{(z+1)(z+2)}$ as a Laurent's series about $z=-2$.	Remember	-	CO 3
15	Solve the value of $\oint\limits_C \frac{1-2z}{z(z-1)(z-2)}dz$ where C is circle $\lvert z\rvert = \frac{1}{2}$ by Cauchy's Residue theorem.	Understand	Learner to recall Cauchy's Residue theorem and apply those formulas to find integral.	CO 4

16	State Residue formulae for simple pole	Remember	-	CO 4
17	Explain the types of evaluation of integrals by Cauchy's Residue theorem.	Remember	Learner to recall Cauchy's Residue theorem and classify the types to find integral.	CO 4
18	Find the Residues of the function $f(z) = \frac{z}{(z-1)(z-2)}$ as a Laurent's series about $z = -1$.	Remember	—	CO 4
19	Define the radius and region of convergence of a power series.	Remember	—	CO 4
20	Define the residue of a function by Laurent series expansion	Remember	—	CO 3
MODULE IV				
SPECIAL FUNCTIONS-I				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Show that $\beta\left(m,n\right) = \int_0^1 \frac{x^{m-1}+x^{n-1}}{(1+x)^{m+n}}dx$	Understand	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them	CO 5
2	Find the value of $\int\limits_0^1 \frac{dx}{\sqrt{1-x^n}}$ in terms of gamma function	Apply	-	CO 5
3	Find the value of i)$\int\limits_0^1 \frac{dx}{\sqrt{1-x^n}}$ ii)$\int\limits_a^b (a-x)^m(x-b)^n dx, b > a$ using Beta-Gamma functions	Apply	-	CO 5
4	Find the value of $\int\limits_0^\infty \frac{dx}{1+x^4}$ using Beta-Gamma functions.	Apply	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them	CO 5
5	Prove that $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$where$m > 0, n > 0$	Apply	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them.	CO 5

6	Prove that $4\int_0^\infty \frac{x^2}{\sqrt{1+x^4}}dx = \sqrt{2\pi}$ using Beta function	Understand	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them	CO 5
7	Prove that $\Gamma(n)\Gamma(1-n)$ $=\frac{\pi}{sinn\pi}$	Apply	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them	CO 5
8	Show that $\beta\left(m+\frac{1}{2}, m+\frac{1}{2}\right) = \frac{\pi}{m.2^{4m-1}} \cdot \frac{1}{\beta(m,m)})$	Understand	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them.	CO 5
9	Show that $\int\limits_0^1 x^m (logx)^n dx = \frac{(-1)^m n!}{(m+1)^{n+1}}$ where n is a positive integer	Understand	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them	CO 5
10	Show that $\int\limits_0^1 y^{q-1}\left(\log\frac{1}{y}\right)^{p-1} dx = \frac{\gamma(p)}{(q)^p}$ where p,q are positive integers	Understand	Leaner to recall the beta-gamma relation and understand the concept to find different relation between them	CO 5
PART-B LONG ANSWER QUESTIONS				
1	Show that $\frac{\beta(m+1,n)}{m} = \frac{\beta(m.n+1)}{n} = \frac{\beta(m,n)}{m+n}$	Apply	This would require the leaner to recall the beta function and understand the different standard form of beta function.	CO 5
2	Show that $\beta(m,n) = \beta(m+1.n) + \beta(m,n+1)$	Understand	This would require the leaner to recall the beta function and understand the different standard form of beta function	CO 5
3	Prove that $\int\limits_0^{\frac{\pi}{2}} \frac{1}{\sqrt{sin\theta}}d\theta \int\limits_0^{\frac{\pi}{2}} \sqrt{sin\theta}\ d\theta = \pi$	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation	CO 5

4	Solve the integral $\int_0^a x^4\sqrt{a^2-x^2}dx$ using Beta-Gamma functions	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
5	Solve the integral $\int_0^1 (x\log x)^4 dx$using Gamma function	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
6	Solve the integral $\int_0^\infty x^{-3/2}(1-e^{-x})dx$	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation	CO 5
7	Solve the integral $\int_0^\infty \sqrt{x}\ e^{-x/3}\ dx$ using Gamma function	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
8	Show that $\Gamma(n) = \int_0^1 \left(\log\frac{1}{x}\right)^{n-1}dx$	Understand	This would require the leaner to recall the beta-gamma relation and apply them for solving improper integrals	CO5
9	Show that $\beta(n,n) = \frac{\sqrt{\pi}\gamma(n)}{2^{2n-1}\gamma\left(n+\frac{1}{2}\right)}$	Understand	This would require the leaner to recall the beta-gamma relation and apply them for solving improper integrals	CO 5
10	Solve the integral $\int_0^1 \frac{x^8(1-x^6)}{(1+x)^{24}}dx$ using Beta - Gamma functions	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5

11	Show that $\int\limits_0^\infty x^m e^{-ax^n} dx = \frac{1}{na^{\frac{m+1}{n}}} \Gamma\left(\frac{1+m}{n}\right)$ where m and n are positive constants	Understand	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
12	Prove that $\Gamma\left(\frac{1}{n}\right).\Gamma\left(\frac{2}{n}\right)\Gamma\left(\frac{3}{n}\right).......\Gamma\left(\frac{n-1}{n}\right) = \frac{(2\pi)^{\frac{n-1)}{2}}}{n^{\frac{1}{2}}}$ where n are positive constant	Understand	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
13	Solve the integral $\int\limits_0^{\frac{\pi}{2}} (\sqrt{Tan\theta} + \sqrt{Sec\theta}) d\theta$ using Beta-Gamma functions	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
14	Solve the integral $\int\limits_0^\infty 3^{-4x^2} dx$	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
15	Solve the integral $\int\limits_0^1 \frac{1}{\sqrt{(-logx)}}\ dx$ using Gamma function	Understand	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
16	Show that $\int\limits_0^\infty e^{-y^{1/m}} dy = m\gamma\left(m\right)$	Understand	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5

17	Solve the integral $\int_0^2 \left(8 - x^3\right)^{1/3} dx$ using Beta-Gamma functions	Understand	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
18	Solve the integral $\int_0^1 \left(1 - x^3\right)^{1/3} dx$ using Beta-Gamma functions	Apply	This would require the leaner to recall the beta-gamma relation and understand how to find improper integrals by applying beta-gamma relation.	CO 5
19	State and prove the symmetry property of Beta function	Apply	-	CO 5
20	State and prove any two other forms of Beta function	Apply	-	CO 5
PART-C SHORT ANSWER QUESTIONS				
1	Show that the value of $\Gamma\left({}^{1}\!/_{2}\right) = \sqrt{\pi}$	Understand	This would require the leaner to recall the gamma function and understand the concept of solving improper integrals.	CO 5
2	State the value of $\Gamma\left(\frac{-7}{2}\right),\ \Gamma\left(\frac{11}{2}\right)$	Understand	This would require the leaner to recall the gamma function and understand the concept of solving improper integrals.	CO 5
3	Find the value of $\Gamma\left({}^{11}\!/_{2}\right)$	Remember	—	CO 5
4	Define Gamma function	Remember	—	CO 5
5	Define Beta function.	Remember	—	CO 5
6	State relation between Beta and Gamma function	Remember	—	CO 5
7	Find the value of $\int_0^\infty \mathrm{e}^{\mathrm{x}^2}\mathrm{dx}$ using gamma function	Remember	—	CO 5
8	Find the value of $\int_0^\infty x^6 e^{-2x} dx$ using Gamma function	Remember	—	CO 5

9	Find the value of $\int\limits_0^\infty \sqrt{x}e^{-x^2}dx$ using Gamma function	Remember	—	CO 5
10	Solve the integral $\int_0^\infty \mathrm{x}^2\mathrm{e}^{-\mathrm{x}^2}dx$ using Gamma function	Remember	This would require the leaner to recall the gamma function and understand the concept of solving improper integrals to apply for given integral.	CO 5
11	What kind of Eulerian integral is Gamma function?	Remember	—	CO 5
12	What kind of Eulerian integral of Beta function?	Remember	—	CO 5
13	What are the convergent values of Gamma function?	Remember	—	CO 5
14	Find the value of integral $\int_0^\infty \frac{x^2}{\sqrt{1-x^5}}dx$ in terms of Beta function	Remember	—	CO 5
15	Find the value of integral $\int_0^\infty x^4e^{-x^2}dx$ in terms of Beta function	Remember	—	CO 5
16	Find the value of integral $\int_0^\infty x^4\left(\log\frac{1}{x}\right)^3dx$ in terms of Beta function	Remember	—	CO 5
17	Find the value of integral $\int_0^{\frac{\pi}{2}} \sqrt{\tan\theta}\,d\theta$ in terms of Beta function	Remember	—	CO 5
18	Find the value of integral $\int_0^{\frac{\pi}{2}} \sqrt{\sec\theta}\,d\theta$ in terms of Beta function	Remember	—	CO 5
19	State any three properties of Beta function	Remember	—	CO 5
20	Show that $\int_0^1 \frac{x}{\sqrt{1-x^2}}dx = \beta\left(\frac{2}{5},\frac{1}{2}\right)$	Remember	—	CO 5
MODULE V				
SPECIAL FUNCTIONS-II				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Show that $$J_{-n}(x) = (-1)^nJ_n(x)$$ where n is a positive integer.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6

2	Show that $J_n(x) = \frac{1}{\pi}\int_0^{\pi} \cos(n\theta - xsin\theta)\, d\theta$ where $J_n(x)$ is Bessel's function, n being a integer.	Apply	This would require the leaner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
3	Show that $\int\limits_0^1 xJ_n(\alpha\, x)J_n(\beta\, x)\;dx = \begin{cases} 0, if\;\alpha = \beta \\ \frac{1}{2}[J_{n+1}(\alpha)]^2, if\;\alpha \neq \beta \end{cases}$	Analyse	This would require the leaner to recall the Bessel recurrence relation and apply recurrence relations analyse them in different cases for finding orthogonal function to Bessel	CO 6
4	State and prove Generating function of Bessel's functions	Analyse	This would require the leaner to recall the Bessel recurrence relation and apply recurrence relations analyse them in different cases for finding orthogonal function to Bessel	CO 6
5	Show that $\frac{d}{dx}[x^n J_n(x)] = x^n J_{n-1}(x)$	Apply	This would require the leaner to recall the Bessel recurrence relation and apply recurrence relations analyse them in different cases that generates Bessel function.	CO 6
6	Show that $\frac{d}{dx}[x^{-n} J_n(x)] = -x^{-n} J_{n+1}(x)$	Apply	This would require the leaner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
7	Show that $\int J_3(x) + J_2(x) + \frac{2}{x}J_1(x) = 0$	Apply	This would require the leaner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
8	Show that $cosx = J_0 - 2J_2 + 2J_4 - \ldots$	Apply	This would require the leaner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6

9	Show that $sinx = 2(J_1 - J_3 + J_5 - \ldots$	Apply	This would require the leaner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
10	Show that $J_{5/2}(x) = \sqrt{\frac{2}{\pi x}}\left(\frac{3-x^2}{x^2}\sin x - \frac{3}{x}\cos x\right)$	Apply	This would require the leaner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
PART - B: LONG ANSWER QUESTIONS				
1	Show that $\int_0^x x^n J_{n-1}(x)\,dx = x^n J_n(x)$ where $J_n(x)$ is Bessel's function.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
2	Show that $\int_0^x x^{n+1} J_n(x)\,dx = x^{n+1} J_{n+1}(x)$ where $J_n(x)$ is Bessel's function.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
3	Show that $\frac{d}{dx}\left[J_n^2 + J_{n+1}^2\right] = \frac{2}{x}\left[nJ_n^2 - (n+1)\,J_{n+1}^2\right]$ where $J_n(x)$ is Bessel's function.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
4	Show that $\frac{d}{dx}\left[xJ_n(x)\,J_{n+1}(x)\right] = x\left[J_n^2(x) - J_{n+1}^2(x)\right]$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
5	Show that $J_n(x)$ is an even function when n is even and an odd function when n is odd function	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
6	Show that $\int J_3(x)\,dx = -J_2(x) - \frac{2}{x}J_1(x)$ using Bessel's Recurrence relation.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6

7	Make use of the generating function to show that $\cos(x\sin\theta) = J_0 + 2(J_2\cos 2\theta + J_4\cos 4\theta + ...)$	Analyse	This would require the learner to recall the Bessel recurrence relation and apply them finding trigonometric relations in term of Bessel functions	CO 6
8	Make use of generating function to show that $\sin(x\sin\theta) = 2(J_1\sin\theta + J_3\sin 3\theta + J_5\sin 5\theta.......)$	Analyse	This would require the learner to recall the Bessel recurrence relation and apply them finding trigonometric relations in term of Bessel functions	CO 6
9	Show that $J_n(-x) = (-1)^n J_n(x)$ where n is a positive or negative integer.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
10	Show the Bessel's recurrence relation $x{J_n}'(x) = nJ_n(x) - xJ_{(n+1)}(x)$.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
11	Show the Bessel's recurrence relation $xJ_n(x) = -nJ_n(x) + xJ_{(n-1)}(x)$.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
12	Show that $J_{3/2}(x) = \sqrt{\frac{2}{\pi x}}\left(\frac{1}{x}\sin x - \cos x\right)$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
13	Relate $J_5(x)$ in terms of $J_0(x)$ and $J_1(x)$	Understand	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
14	Show that $\int {J_0}^2(x)\,dx = \frac{1}{2}x^2\left[{J_0}^2(x) + {J_1}^2(x)\right]$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6

15	Show that $\frac{n}{x}J_n\left(x\right)+{J_n}'\left(x\right)=J_{n-1}\left(x\right)$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
16	Show that $J_0^2+2\left(J_1^2+J_2^2+J_3^2+\ldots\right)=1$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
17	Show that $J_0^2+2\left(J_1^2+J_2^2+J_3^2+\ldots\right)=1$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
18	Show the Bessel's recurrence relation $J_n(x)=1/2[J_{(n-1)}(x)-J_{(n+1)}(x)]$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
19	Show the Bessel's recurrence relation $J_{1/2}(x)=\sqrt{\frac{2}{\pi x}}\sin x$.	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
20	Show the Bessel's recurrence relation $J_{-1/2}(x)=\sqrt{\frac{2}{\pi x}}\cos x$	Apply	This would require the learner to recall the Bessel recurrence relation and apply them to prove different relation	CO 6
PART-C SHORT ANSWER QUESTIONS				
1	State the expansion of $J_n(x)$.	Remember	—	CO 6
2	State the expansion of $J_n\left(-x\right)$	Remember	—	CO 6
3	State Bessel differential equation.	Remember	—	CO 6
4	State the most general solution of Bessel differential equation	Remember	—	CO 6
5	State the expansion of $J_0(x)$.	Remember	—	CO 6

6	Relate $J_2(x)$ in terms of $J_0(x)$ and $J_1(x)$	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relation.	CO 6
7	Relate $J_3(x)$ in terms of $J_0(x)$ and $J_1(x)$	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relation.	CO 6
8	Relate $J_4(x)$ in terms of $J_0(x)$ and $J_1(x)$	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relation.	CO 6
9	State the relationship between $J_n(x), J_{n-1}(x)\, and\, J_{n+1}(x)$	Remember	—	CO 6
10	State the relationship between $J_n{}'(x), J_{n-1}(x)\ \ and\ J_{n+1}(x)$	Remember	—	CO 6
11	Show that $$\left[J_{\frac{1}{2}}\right]^2 + \left[J_{-\frac{1}{2}}\right]^2 = \frac{2}{\pi x}$$	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relation.	CO 6
12	Show that $J_n(x) = 0$ has no repeated roots except at $x = 0$.	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relations.	CO 6
13	Show that $\frac{d}{dx}(J_1(x)) = -J_1(x)$. where $J_n(x)$ is the Bessel's function.	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relations.	CO 6
14	State the trigonometric expansion of $\cos(xsin\theta)$	Remember	—	CO 6
15	State the trigonometric expansion of $\sin(xsin\theta)$	Remember	—	CO 6
16	State Orthogonality Property of Bessel's functions	Remember	—	CO 6

17	State the property of Generating function of Bessel's functions	Remember	—	CO 6
18	Relate $J_{3/2}\left(x\right)$ in terms of sine and cosine trigonometric ratios	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relation.	CO 6
19	Relate $J_{5/2}\left(x\right)$ in terms of sine and cosine trigonometric ratios	Understand	This would require the learner to recall the Bessel recurrence relation and understand them to prove different relation.	CO 6
20	Show that $J_{-1/2}\left(x\right) = J_{1/2}\left(x\right).cotx$	Apply	—	CO 6

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HOD ECE