22MA110	CALCULUS FOR ENGINEERS

Category	L	T	P	Credit
BS	3	1	0	4

Preamble

This course aims to provide technical competence of modeling engineering problems using calculus. Th course implements the calculus concepts geometrically, numerically, algebraically and verbally. Studen will apply the main tools for analyzing and describing the behavior of functions of single and mul variables: limits, derivatives, integrals of single and multi-variables to model and solve compl engineering problems using analytical methods and MATLAB.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO's	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Cognize the concept of functions, limits and continuity	TPS2	75	70
CO2	Compute derivatives and apply them in solving engineering problems	TPS3	70	65
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	TPS3	70	65
CO4	Demonstrate the techniques of integration to find the surface area of revolution of a curve.	TPS3	70	65
CO5	Utilize double integrals to evaluate area enclosed between two curves.	TPS3	70	65
CO6	Apply triple integrals to find volume enclosed between surfaces	TPS3	70	65

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="6">Assessment 1</th><th colspan="6">Assessment 2</th><th colspan="4" rowspan="2">Terminal
(%)</th></tr>
<tr><th colspan="3">Written Test 1 (%)</th><th colspan="3">Assignment 1 (%)</th><th colspan="3">Written Test 2 (%)</th><th colspan="3">Assignment 2 (%)</th></tr>
<tr><th>TPS</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>TOTAL (%)</th></tr>
<tr><td>CO1</td><td colspan="3">20%</td><td colspan="3" rowspan="3">50%</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>10%</td><td>-</td><td>10%</td></tr>
<tr><td>CO2</td><td colspan="3">32%</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td>16%</td><td>16%</td></tr>
<tr><td>CO3</td><td colspan="3">36%</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td>18%</td><td>18%</td></tr>
<tr><td>CO4</td><td colspan="3">12%</td><td colspan="3">-</td><td colspan="3">39%</td><td colspan="3" rowspan="3">50%</td><td>-</td><td>-</td><td>25%</td><td>25%</td></tr>
<tr><td>CO5</td><td colspan="3">-</td><td colspan="3">-</td><td colspan="3">35%</td><td>-</td><td>-</td><td>17%</td><td>17%</td></tr>
<tr><td>CO6</td><td colspan="3">-</td><td colspan="3">-</td><td colspan="3">26%</td><td>-</td><td>-</td><td>14%</td><td>14%</td></tr>
<tr><td>MATLAB</td><td colspan="3">-</td><td colspan="3">50%</td><td colspan="3">-</td><td colspan="3">50%</td><td></td><td></td><td></td><td></td></tr>
<tr><td>TOTAL</td><td colspan="3">100%</td><td colspan="3">100%</td><td colspan="3">100%</td><td colspan="3">100%</td><td>-</td><td>10%</td><td>90%</td><td>100 %</td></tr>
</table>

* Assignment 1: (i)Application Problems in CO1, CO2 and CO3 (50%).
(ii) MATLAB Onramp& Introduction to symbolic Math with MATLAB (50%).

**Assignment 2: (i) Application Problems in CO4, CO5 and CO6 (50%).
(ii) Application problems using MATLAB. (50%).

***Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

DIFFERENTIAL CALCULUS

Functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Maxima and Minima of functions of one variable – Mean value theorem - Effect of derivatives on the shape of a graph- Application problems in engineering using MATLAB.

[13 hours]

FUNCTIONS OF SEVERAL VARIABLES:

Function of several variables- Level curves and level surfaces - Partial derivatives – Chain rule - Maxima and minima of functions of two variables –Method of Lagrange's Multipliers - Application problems in engineering using MATLAB. [9 hours]

INTEGRAL CALCULUS:

The definite integral – Fundamental theorem of Calculus – Indefinite integrals and the Net Change Theorem – Improper integrals – Area of surface of revolution - Volume of solid of revolution -Application problems in engineering using MATLAB. [12 hours]

MULTIPLE INTEGRALS:

Iterated integrals-Double integrals over general regions-Double integrals in polar coordinates- Applications of double integrals (density, mass, moments & moments of inertia problems only)- triple integrals- triple integrals in cylindrical coordinates- triple integrals in spherical coordinates- change of variables in multiple integrals - Application problems in engineering using MATLAB.

[14 hours]

Text Book

1) James Stewart, "Calculus Early Transcendentals", 9e, Cengage Learning, New Delhi, 2019.

DIFFERENTIAL CALCULUS: [Sections: 1.3, 2.2, 2.5, 2,6,2.8, 4.1, 4.2 and 4.3.]
FUNCTIONS OF SEVERAL VARIABLES: [Sections: 14.1,14.3,14.5,14.7 and 14.8.]
INTEGRAL CALCULUS: [Sections: 5.2, 5.3, 5.4, 7.8, 8.2 and 6.2.]
MULTIPLE INTEGRAL: [Sections: 15.1-15.4, 15.6-15.9]

2) Lecture Notes on Calculus Through Engineering Application Problems and Solutions, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

Reference Books

1) George B. Thomas, "Thomas Calculus: early Transcendentals", ,14th e ,Pearson,New Delhi, 2018.
2) Howard Anton, Irl Bivens and Stephen Davis, "Calculus: Early Transcendentals", 12th e, John Wiley&Sons, 2021.
3) Kuldeep Singh, "Engineering Mathematics Through Appplications",2nd e, Blooms berry publishing, 2019,
4) Kuldip S. Rattan, Nathan W. Klingbeil, Introductory Mathematics for Engineering Applications, 2nd e John Wiley& Sons , 2021.

Course Contents and Lecture Schedule

Module No / Text Book Sec	Topic	No. of Periods	COs
1	**DIFFERENTIAL CALCULUS**		
1.1 / 1.3	Functions and New functions from old functions	2	CO1
1.2 / 2.2 & 2.5	Limit of a function &Continuity of a function	1	CO1
	Tutorial	**1**	
1.3 / 2.6	Limits at infinity	1	CO1
1.4 / 2.8	Derivative as a function	2	CO2
	Tutorial	**1**	
1.5 / 4.1	Maxima and Minima of functions of single variable	2	CO2
1.6 / 4.2 & 4.3	The Mean value theorem and effect of derivatives on the shape of a graph of a function	1	CO2
	Tutorial	**1**	
1.7	Application problems in engineering using MATLAB	1	
2	**FUNCTIONS OF SEVERAL VARIABLES**		
2.1 / 14.1	Level curves and level surfaces	2	CO3
2.2 / 14.3 & 14.5	Partial derivatives – Chain rule	1	CO3
	Tutorial	**1**	
2.3 / 14.7	Maxima and minima of functions of two variables	2	CO3
2.4 / 14.8	Method of Lagrange's Multipliers	1	CO3
	Tutorial	**1**	
2.5	Application problems in engineering using MATLAB	1	
3	**INTEGRAL CALCULUS**		
3.1 / 5.2	The definite integral	1	CO4
3.2 / 5.3	Fundamental theorem of Calculus	2	CO4
	Tutorial	**1**	
409 3.3 / 5.4	Indefinite integrals and the Net Change Theorem	1	CO4
542 3.4 / 7.8	Improper integrals	2	CO4
	Tutorial	**1**	
567 3.5 / 8.2	Area of surface of revolution	1	CO4
446 3.6 / 6.2	Volume of solid of revolution.	2	CO4
3.7	Application problems in engineering using MATLAB	1	
1043 4	**MULTIPLE INTEGRALS**		
4.1 / 15.1	Iterated integrals	1	CO5
1051 4.2 / 15.2	Double integrals over general regions	2	CO5
	Tutorial	**1**	

1062	4.3 / 15.3	Double integrals in polar coordinates	1	CO5	
1069	4.4 / 15.4	Applications of double integrals (density, mass, moments & moments of inertia problems only)	2	CO5	
		Tutorial	1		
1082	4.5 / 15.6	Triple integrals	1	CO6	
1095	4.6 / 15.7	Triple integrals in cylindrical coordinates	1	CO6	
1103	4.7 / 15.8	Triple integrals in spherical coordinates	1	CO6	
		Tutorial	1		
1109	4.8 / 15.9	Change of variables in multiple integrals	1	CO6	
	4.9	Application problems in engineering using MATLAB	1		
		Total	**48**		

ASSIGNMENT 1

Part A **(Remember)**

Book	CP	Sl
1.3	1.1	1. Define various translations of a function.
		2. Define various stretching and reflections of a function.
		3. Define the composition of functions.
		4. Define the sum, difference, product and quotient of functions with examples.
		5. Is the composition of functions commutative. Justify with an example.
		6. Is the composition of function associative. Justify with an example.
2.2	1.2	7. Define the limit, left hand and right-hand limit and state the relation between them.
		8. Define infinite limits.
		9. Define: Vertical Asymptote.
2.5	1.2	10. Define: Continuity and Dis-continuity of a function.
		11. State the types of discontinuities and define them.
		12. Define the continuity of a function in an interval.
		13. State the properties of continuity. Is a polynomial function continuous @ Everywhere?
		14. State the type of functions that are continuous at every number in their domain.
		15. Is the composition of functions is Continuous? Justify with a example.
		16. State Intermediate value theorem.
2.6	1.3	17. Define: Horizontal asymptote
		18. If $r > 0$; $\lim\limits_{x\to\infty} \frac{1}{x^r} = ?$ and $\lim\limits_{x\to -\infty} \frac{1}{x^r} = ?$
		19. Define the limit of a function in an interval.
		20. Define: Limit at infinity.
		21. Define: Infinite Limit at infinity.
2.8	1.4	22. Define the derivative for a function at a number x= a.
		23. Define the derivative as a function.
		24. Define: Differentiability.
		25. Is a differentiable function continuous? Is the converse true? Justify.
		26. Define: Higher derivatives.
		27. What is the name for the third derivative of the position function?
		28. State the constant multiple rule, sum rule, difference rule for derivative.
4.1	1.5	29. Define: i)Absolute maximum ii) Absolute minimum of a function in a domain D.
		30. Define: Local maximum and local minimum @ a point c.
		31. State: I) Extreme value theorem. II) Fermat's theorem.
		32. Explain Closed Interval method.
4.2	1.6	33. State Rolle's theorem
		34. State the mean value theorem
4.3	1.6	35. Define: Increasing and decreasing function.

36. State the first derivative test for Increasing and decreasing function.
37. Define: Concave upward and concave downward of a function in an interval.
38. State Concavity test
39. Define the Point of inflexion
40. Describe the Second derivative test

14.1 2.1 41. Define a graph of functions of two variables.
42. Define level curves and contour maps.

14.3 2.2 43. Define the Partial derivatives of a function of two variables.
44. State the various notations on partial derivatives.
45. State the rule for finding the partial derivatives.
46. State the notations for the higher order partial derivatives.
47. State Clairaut's Theorem.
48. What is a PDE. Give an example.
49. State: The Laplace Equation. The wave equation.

14.5 2.2 50. State the chain rule 1 for partial derivatives.
51. State the chain rule 2 for partial derivatives.
52. State the general version of Chain Rule.
53. State the rule for Implicit partial differentiation.

14.7 2.3 54. Define the Local maximum and Local minimum of a function of two variables.
55. Define the Absolute maximum and Absolute minimum of a function of two variables.
56. State the theorem on Local maximum or minimum related to the partial derivatives.
57. Define: Critical point or Stationary point.
58. State the Second derivative test for Local maximum or Local minimum of a function of two variables
59. Define: Saddle point. Express in terms of second derivative test.
60. Define: i) Closed set in R^2 ii) Bounded set in R^2
61. State the Extreme value theorem for functions of two variables.
62. State the various steps (Extension of the closed interval method) in finding the Absolute maximum and minimum values of a continuous function on a closed, bounded set D.

14.8 2.4 63. Describe the method of Lagrange Multipliers to find the maximum and minimum values of f(x, y,z) subject to the constraint g(x,y,z).
64. Describe the method of Lagrange Multipliers to find the maximum and minimum values of f(x,y,z) subject to the constraints g(x,y,z) and h (x, y,z).

Part B	(understand / Apply)	
(Book)	CP	
Ex 1.3	1.1	Problems:2,5,6,11,19,21,31,37,43,46,51,58,67,70.
Ex 2.2	1.2	Problems:1,3,5,7,9,11,16,20,23,26
Ex 2.5	1.2	Problems:3,11, 13, 20,24, 27,37, 42,45,51
Ex 2.6	1.3	Problems:2,5,11,20,33,47,49,53,60,73.
Ex 2.8	1.4	Problems: 1,7,11,14, 24,29,33,36,51,66
Ex 4.1	1.5	Problems:5,12,15,20,25,31,32,51,69,70
Ex 4.2	1.6	Problems: 4,6,9,10,22,24,25,29,31,
Ex 4.3	1.6	Problems: 2,8,10,17,23,35,37,45,59,69
Ex 14.1	2.1	Problems: 1, 7, 11, 24, 28, 45, 47, 53, 57, 67, 73
Ex 14.3	2.2	Problems: 9, 12, 18, 28, 40, 42, 45, 49, 54, 57, 78
Ex 14.5	2.2	Problems: 1, 5, 9, 11, 17, 21, 25, 31, 36, 51
Ex 14.7	2.3	Problems: 1(a), 2(c), 5, 8, 17, 25, 30, 33, 44, 52
Ex 14.8	2.4	Problems: 4, 6, 18, 23, 25, 28, 31, 41, 59

ASSIGNMENT 2

Part A		(Remember)
Book	CP	Sl
5.2	3.1	1. Define: Definite integral with all components.
		2. What is Integration?
		3. State the theorem on the existence of definite integral.
		4. State the Theorem on integrability in term of limit sum.
		5. State the Midpoint Rule for definite integral.
		6. State the Basic properties of definite integral.
		7. State the Property to combine integrals of the same function over adjacent intervals.
		8. State the Comparison properties of definite integrals.
5.3	3.2	9. State Part 1 of the Fundamental theorem of calculus.
		10. State Part 2 of the Fundamental theorem of calculus.
		11. State the Fundamental theorem of calculus.
5.4	3.3	12. Define: Indefinite integral
		13. List the table of standard indefinite integrals.
		14. State: Net change theorem.
		15. Use Net change theorem to define: i) the rate at which the water flows in to the reservoir ii) the rate of reaction of the product of a chemical iii) mass of the segment of a rod iv) the net change in the population v) the increase in cost vi) the net change of position

		vii) The total distance travelled.
		viii) The acceleration of the object.
7.8	3.4	16. Define improper integrals of type 1 and when they are convergent / divergent.
		17. Define improper integrals of type 2 and when they are convergent / divergent.
		18. State the comparison test / theorem for improper integrals.
8.2	3.5	19. Define: The surface area of rotation about i) X axis ii) Y axis in terms of definite integral.
6.2	3.6	20. Define: Volume of revolution about x and y axes in terms of definite integral.
15.1	4.1	21. Define double integral
		22. State the Midpoint rule for double integrals.
		23. Define Iterated Integral
		24. State Fubini's theorem for double integral.
15.2	4.2	25. Define: The double integral over type I region.
		26. Define: The double integral over type 2 region.
		27. State the properties of double integrals.
15.3	4. 3	28. State the relation between rectangular and polar coordinates.
		29. Recall the relation for the change from cartesian to polar coordinates in double integrals
		30. State the relation for double integral in polar coordinates.
15.4	4. 4	31. Define: Density and mass.
		32. Define: Mass in terms of double integral
		33. Define Charge in terms of double integral
		34. Define: Moment about i) X axis ii) Y axis
		35. Give expressions for the coordinates for the Centre of mass.
		36. Define: The moment of inertia of a lamina about x and y axes.
		37. Define: Define the polar moment of inertia or moment of inertia about the origin.
		38. Define the radius of gyration of a lamina about an axis.
		39.Define the radius of gyration of a lamina about i) X axis ii) Y axis
15.6	4.5	40. Define a rectangular box.
		41. Define the triple integral as a Riemann Sum
		42. Define the triple integral as a limit sum.
		43. State Fubini's theorem for triple integrals.
		44. Define: a triple integral over a general bounded region E.
		45.Define: Type I, Type II and Type III plane regions.
		46.Define the volume in terms of triple integral in terms of type I, II & III regions.
		47. Define: Mass in terms of triple integral.
		48. Define: the moments about the coordinate planes.
		49. Define: Centre of mass in terms of triple integral.

50. Define centroid.

51. If the density is constant, give the expressions for the moments of inertia about the coordinate axes.

52. Define: The total charge Q in terms of triple integral.

15.7 4.6 53. How a point is represented in cylindrical coordinate system?

54. Write down the equations of transformation from cartesian to cylindrical coordinates.

55. Give the formula for triple integrals in cylindrical coordinates.

15.8 4.7 56. How a point is represented in Spherical coordinate system?

57. Write down the equations of transformation from cartesian to Spherical coordinates.

58. Give the formula for triple integrals in spherical coordinates

15.9 4.8 59. Explain the change of variables that is given by a transformation T from the uv plane to the xy plane. How it is called otherwise?

60. Define the Jacobian of the transformation given by $x = g(u, v)$ and $y = h(u, v)$.

61. Define the Jacobian of the transformation given by $x = g(u, v, w)$ and $y = h(u, v, w)$ and $z = k(u, v, w)$

62. State The theorem related to the change of variables in triple integral and hence formula for evaluating in terms of spherical coordinates.

Part-B (understand / Apply)

(Book)	**CP**	
Ex 5.2	3.1	Problems: 3, 7, 10, 12, 19, 25, 27, 34, 51, 60
Ex 5.3	3.2	Problems: 3, 8, 12, 18, 21, 25, 34, 41, 50, 58
Ex 5.4	3.3	Problems: 5, 7, 18, 24, 26, 28, 31, 41, 69, 71.
Ex 7.8	3.4	Problems: 1, 5, 10, 19, 35, 49, 57, 61, 65, 69
Ex 8.2	3.5	Problems: 2, 5, 11, 17, 23, 27, 29, 32, 40(b).
Ex 6.2	3.6	Problems 2,8,14,22,28,33,38,40,54
Ex 15.1	4.1	Problems: 3, 9,13, 17, 22, 28,34,37
Ex 15.2	4.2	Problems: 3,8, 12, 17, 22, 24, 36, 44
Ex 15.3	4.3	Problems: 1, 10, 21, 28, 32,36,41
Ex 15.4	4.4	Problems: 1, 5,10, 20, 29,30, 33
Ex 15.6	4.5	Problems: 4, 10, 15, 17, 24,28, 32, 36
Ex 15.7	4.6	Problems: 3, 9, 18, 21, 32
Ex 15.8	4.7	Problems: 9, 12, 17, 25, 32, 37, 43
Ex 15.9	4.8	Problems: 3,8, 12, 15(a), 21, 27

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