

# MA633L-Numerical Analysis

Lecture 1 : Introduction - What? Why? How?

**Panchatcharam Mariappan<sup>1</sup>**

<sup>1</sup>Associate Professor  
Department of Mathematics and Statistics  
IIT Tirupati, Tirupati

January 9, 2025





# About the Course

# Introduction



- Solving mathematical problems require more practical effort
- Listen to Lectures, Read Books and Try to Solve Problems
- If you do not solve problems, you delude yourself that you understand everything, you will be awakened only when first problem you attempt in Quiz-1 or Test-1
- Enough problems are given at the end of each class. Work out those problems before the next class

# Introduction

- Work with this course material, think about it, write your own comments, solve problems and make yourself comfortable. If you follow this, problems will be familiar to you like finding your home in a street where you live as you wandered around your home many times, otherwise, solving the problem will be like trying to locate your home from the map locations.



# Introduction

- Instructor helps you to understand each topic thoroughly, rather than remember how to go through the mechanics of a proof or calculation
- If you memorize the proof and calculation, it will be retained in your brain until examination and will be erased afterwards



# Introduction



- Attend lectures, reread the lecture notes, correct mistakes of them
- Read reference books and text books, correlate with lecture notes
- Solve problems from lecture notes, books, past exam papers
- Discuss the subject with your friends and colleagues
- Convincingly explain the topic to your friends so that you will really understand it yourself.

# Marks (Tentative)



<b>Component</b>	<b>Marks</b>	<b>Topics</b>
Test-1	20	Till Jan 31, 2025 Covered
Test-2	20	Till Feb 22, 2025 Covered
End Semester Theory	60	All : 3 Hours Exam



# Numerical Analysis: What? Why? How?



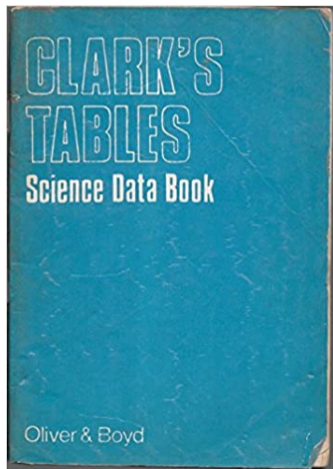
# Numerical Analysis



- A study of algorithms that use numerical approximation for the problems of mathematical analysis.
- Area of mathematics and computer science that creates, analyzes, and implements algorithms for solving numerically the problems of mathematics.
- Problems originate from real world applications, engineering, natural sciences, medicine and so on.

# Numerical Analysis: School Memories

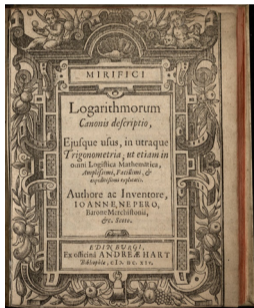
- Numerical Approach to Natural Logarithms



# Numerical Analysis: School Memories



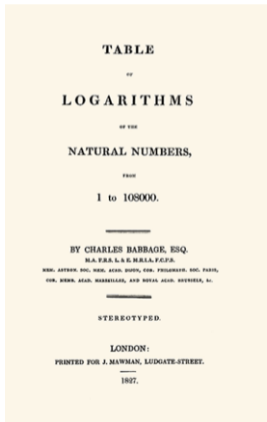
- Numerical Approach to Natural Logarithms:



# Numerical Analysis: School Memories



- Numerical Approach to Natural Logarithms: Greatest Discovery of 16th Century



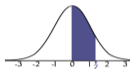
Log. 000. N. 100.

Log.	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
0	0.0000000	0.0000434	0.0000868	0.0001302	0.0001736	0.0002170	0.0002604	0.0003038	0.0003472	0.0003906	0.0004340
1	0.0004774	0.0005208	0.0005642	0.0006076	0.0006510	0.0006944	0.0007378	0.0007812	0.0008246	0.0008680	0.0009114
2	0.0009548	0.0010012	0.0010476	0.0010940	0.0011404	0.0011868	0.0012332	0.0012796	0.0013260	0.0013724	0.0014188
3	0.0014652	0.0015116	0.0015580	0.0016044	0.0016508	0.0016972	0.0017436	0.0017900	0.0018364	0.0018828	0.0019292
4	0.0019756	0.0020220	0.0020684	0.0021148	0.0021612	0.0022076	0.0022540	0.0023004	0.0023468	0.0023932	0.0024396
5	0.0024860	0.0025324	0.0025788	0.0026252	0.0026716	0.0027180	0.0027644	0.0028108	0.0028572	0.0029036	0.0029500
6	0.0029964	0.0030428	0.0030892	0.0031356	0.0031820	0.0032284	0.0032748	0.0033212	0.0033676	0.0034140	0.0034604
7	0.0035068	0.0035532	0.0035996	0.0036460	0.0036924	0.0037388	0.0037852	0.0038316	0.0038780	0.0039244	0.0039708
8	0.0040172	0.0040636	0.0041100	0.0041564	0.0042028	0.0042492	0.0042956	0.0043420	0.0043884	0.0044348	0.0044812
9	0.0045276	0.0045740	0.0046204	0.0046668	0.0047132	0.0047596	0.0048060	0.0048524	0.0048988	0.0049452	0.0049916
10	0.0050380	0.0050844	0.0051308	0.0051772	0.0052236	0.0052700	0.0053164	0.0053628	0.0054092	0.0054556	0.0055020
11	0.0055484	0.0055948	0.0056412	0.0056876	0.0057340	0.0057804	0.0058268	0.0058732	0.0059196	0.0059660	0.0060124
12	0.0060588	0.0061052	0.0061516	0.0061980	0.0062444	0.0062908	0.0063372	0.0063836	0.0064300	0.0064764	0.0065228
13	0.0065692	0.0066156	0.0066620	0.0067084	0.0067548	0.0068012	0.0068476	0.0068940	0.0069404	0.0069868	0.0070332
14	0.0070796	0.0071260	0.0071724	0.0072188	0.0072652	0.0073116	0.0073580	0.0074044	0.0074508	0.0074972	0.0075436
15	0.0075840	0.0076304	0.0076768	0.0077232	0.0077696	0.0078160	0.0078624	0.0079088	0.0079552	0.0080016	0.0080480
16	0.0080944	0.0081408	0.0081872	0.0082336	0.0082800	0.0083264	0.0083728	0.0084192	0.0084656	0.0085120	0.0085584
17	0.0086048	0.0086512	0.0086976	0.0087440	0.0087904	0.0088368	0.0088832	0.0089296	0.0089760	0.0090224	0.0090688
18	0.0091152	0.0091616	0.0092080	0.0092544	0.0093008	0.0093472	0.0093936	0.0094400	0.0094864	0.0095328	0.0095792
19	0.0096296	0.0096760	0.0097224	0.0097688	0.0098152	0.0098616	0.0099080	0.0099544	0.0100008	0.0100472	0.0100936
20	0.0101400	0.0101864	0.0102328	0.0102792	0.0103256	0.0103720	0.0104184	0.0104648	0.0105112	0.0105576	0.0106040
21	0.0106504	0.0106968	0.0107432	0.0107896	0.0108360	0.0108824	0.0109288	0.0109752	0.0110216	0.0110680	0.0111144
22	0.0111608	0.0112072	0.0112536	0.0113000	0.0113464	0.0113928	0.0114392	0.0114856	0.0115320	0.0115784	0.0116248
23	0.0116712	0.0117176	0.0117640	0.0118104	0.0118568	0.0119032	0.0119496	0.0119960	0.0120424	0.0120888	0.0121352
24	0.0121816	0.0122280	0.0122744	0.0123208	0.0123672	0.0124136	0.0124600	0.0125064	0.0125528	0.0125992	0.0126456
25	0.0126920	0.0127384	0.0127848	0.0128312	0.0128776	0.0129240	0.0129704	0.0130168	0.0130632	0.0131096	0.0131560
26	0.0132024	0.0132488	0.0132952	0.0133416	0.0133880	0.0134344	0.0134808	0.0135272	0.0135736	0.0136200	0.0136664
27	0.0137128	0.0137592	0.0138056	0.0138520	0.0138984	0.0139448	0.0139912	0.0140376	0.0140840	0.0141304	0.0141768
28	0.0142232	0.0142696	0.0143160	0.0143624	0.0144088	0.0144552	0.0145016	0.0145480	0.0145944	0.0146408	0.0146872
29	0.0147336	0.0147800	0.0148264	0.0148728	0.0149192	0.0149656	0.0150120	0.0150584	0.0151048	0.0151512	0.0151976
30	0.0152440	0.0152904	0.0153368	0.0153832	0.0154296	0.0154760	0.0155224	0.0155688	0.0156152	0.0156616	0.0157080
31	0.0157544	0.0158008	0.0158472	0.0158936	0.0159400	0.0159864	0.0160328	0.0160792	0.0161256	0.0161720	0.0162184
32	0.0162648	0.0163112	0.0163576	0.0164040	0.0164504	0.0164968	0.0165432	0.0165896	0.0166360	0.0166824	0.0167288
33	0.0167752	0.0168216	0.0168680	0.0169144	0.0169608	0.0170072	0.0170536	0.0171000	0.0171464	0.0171928	0.0172392
34	0.0172856	0.0173320	0.0173784	0.0174248	0.0174712	0.0175176	0.0175640	0.0176104	0.0176568	0.0177032	0.0177496
35	0.0177960	0.0178424	0.0178888	0.0179352	0.0179816	0.0180280	0.0180744	0.0181208	0.0181672	0.0182136	0.0182600
36	0.0183064	0.0183528	0.0183992	0.0184456	0.0184920	0.0185384	0.0185848	0.0186312	0.0186776	0.0187240	0.0187704
37	0.0188168	0.0188632	0.0189096	0.0189560	0.0190024	0.0190488	0.0190952	0.0191416	0.0191880	0.0192344	0.0192808
38	0.0193272	0.0193736	0.0194200	0.0194664	0.0195128	0.0195592	0.0196056	0.0196520	0.0196984	0.0197448	0.0197912
39	0.0198376	0.0198840	0.0199304	0.0199768	0.0200232	0.0200696	0.0201160	0.0201624	0.0202088	0.0202552	0.0203016
40	0.0203480	0.0203944	0.0204408	0.0204872	0.0205336	0.0205800	0.0206264	0.0206728	0.0207192	0.0207656	0.0208120
41	0.0208584	0.0209048	0.0209512	0.0209976	0.0210440	0.0210904	0.0211368	0.0211832	0.0212296	0.0212760	0.0213224
42	0.0213688	0.0214152	0.0214616	0.0215080	0.0215544	0.0216008	0.0216472	0.0216936	0.0217400	0.0217864	0.0218328
43	0.0218792	0.0219256	0.0219720	0.0220184	0.0220648	0.0221112	0.0221576	0.0222040	0.0222504	0.0222968	0.0223432
44	0.0223896	0.0224360	0.0224824	0.0225288	0.0225752	0.0226216	0.0226680	0.0227144	0.0227608	0.0228072	0.0228536
45	0.0228940	0.0229404	0.0229868	0.0230332	0.0230796	0.0231260	0.0231724	0.0232188	0.0232652	0.0233116	0.0233580
46	0.0234044	0.0234508	0.0234972	0.0235436	0.0235900	0.0236364	0.0236828	0.0237292	0.0237756	0.0238220	0.0238684
47	0.0239148	0.0239612	0.0240076	0.0240540	0.0241004	0.0241468	0.0241932	0.0242396	0.0242860	0.0243324	0.0243788
48	0.0244252	0.0244716	0.0245180	0.0245644	0.0246108	0.0246572	0.0247036	0.0247500	0.0247964	0.0248428	0.0248892
49	0.0249356	0.0249820	0.0250284	0.0250748	0.0251212	0.0251676	0.0252140	0.0252604	0.0253068	0.0253532	0.0253996
50	0.0254460	0.0254924	0.0255388	0.0255852	0.0256316	0.0256780	0.0257244	0.0257708	0.0258172	0.0258636	0.0259100
51	0.0259564	0.0260028	0.0260492	0.0260956	0.0261420	0.0261884	0.0262348	0.0262812	0.0263276	0.0263740	0.0264204
52	0.0264668	0.0265132	0.0265596	0.0266060	0.0266524	0.0266988	0.0267452	0.0267916	0.0268380	0.0268844	0.0269308
53	0.0269772	0.0270236	0.0270700	0.0271164	0.0271628	0.0272092	0.0272556	0.0273020	0.0273484	0.0273948	0.0274412
54	0.0274876	0.0275340	0.0275804	0.0276268	0.0276732	0.0277196	0.0277660	0.0278124	0.0278588	0.0279052	0.0279516
55	0.0279980	0.0280444	0.0280908	0.0281372	0.0281836	0.0282300	0.0282764	0.0283228	0.0283692	0.0284156	0.0284620
56	0.0285084	0.0285548	0.0286012	0.0286476	0.0286940	0.0287404	0.0287868	0.0288332	0.0288796	0.0289260	0.0289724
57	0.0290188	0.0290652	0.0291116	0.0291580	0.0292044	0.0292508	0.0292972	0.0293436	0.0293900	0.0294364	0.0294828
58	0.0295292	0.0295756	0.0296220	0.0296684	0.0297148	0.0297612	0.0298076	0.0298540	0.0299004	0.0299468	0.0299932
59	0.0300336	0.0300800	0.0301264	0.0301728	0.0302192	0.0302656	0.0303120	0.0303584	0.0304048	0.0304512	0.0304976
60	0.0305440	0.0305904	0.0306368	0.0306832	0.0307296	0.0307760	0.0308224	0.0308688	0.0309152	0.0309616	0.0310080
61	0.0310544	0.0311008	0.0311472	0.0311936	0.0312400	0.0312864	0.0313328	0.0313792	0.0314256	0.0314720	0.0315184
62	0.0315648	0.0316112	0.0316576	0.0317040	0.0317504	0.0317968	0.0318432	0.0318896	0.0319360	0.0319824	0.0320288
63	0.0320752	0.0321216	0.0321680	0.0322144	0.0322608	0.0323072	0.0323536	0.0324000	0.0324464	0.0324928	0.0325392
64	0.0325856	0.0326320	0.0326784	0.0327248	0.0327712	0.0328176	0.0328640	0.0329104	0.0329568	0.0330032	0.0330496
65	0.0330960	0.0331424	0.0331888	0.0332352	0.0332816	0.0333280	0.0333744	0.0334208	0.0334672	0.0335136	0.0335600
66	0.0336064	0.0336528	0								

# Numerical Analysis: School Memories



- Normal Distribution Table



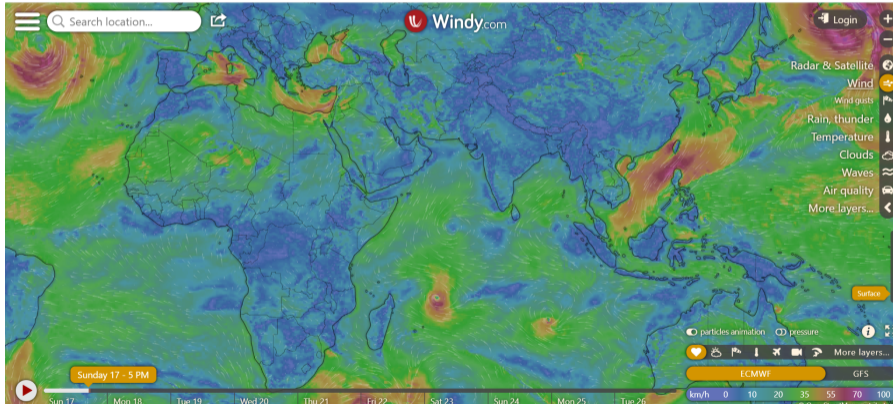
STANDARD NORMAL TABLE (Z)

Entries in the table give the area under the curve between the mean and  $z$  standard deviations above the mean. For example, for  $z = 1.25$  the area under the curve between the mean (0) and  $z$  is 0.3944.

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0190	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2969	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3529	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4238	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4895	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998

# Numerical Weather Prediction

- Weather Prediction



# Numerical Analysis: Car Crash

- Car Crash using Finite Element Analysis



# Numerical Analysis: Rocket/Missile

- Trajectories of Rocket and Missiles





# Numerical Analysis: Applications

- Stock Market
- Aerospace Industry
- All Engineering Disciplines
- Most of the Medical Industries
- Actuarial Analysis
- ⋮



# Numerical Analysis: Areas

- Numerical Solution of System of Linear Equations
- Numerical Solution of System of Nonlinear Equations
- Numerical Optimization
- Numerical Integration
- Numerical Differentiation
- Numerical Interpolation
- Best approximations
- Wavelets
- ⋮





# Numerical Analysis: History

# Historical Background

- Root finding Method: 1650 BC, Egyptian Rhind Papyrus
- Calculating Length, Areas and Volume of Geometric Figures: 400-350 BC Eudoxus, 285 BC Archimedes
- Greek Mathematicians: Trigonometric functions, Chord of a circle to the arc it subtends, Chord function, Hipparchus (140 BC), Ptolemy (140)

“A logarithmic table is a small table by which we can obtain a knowledge of all geometrical dimensions and motions in space, by a very easy calculation.”

*–John Napier*

# Historical Background



- Solving the Cubic equation  $\sin 3\alpha = 3 \sin \alpha - 4 \sin^3 \alpha$ , Al-Kashi (1400)
- Properties of Exponents: Stifel (1487-1567)
- Logarithms Table: John Napier (1550-1617), Burgi (1552-1634)
- Calculus Development : Newton (1642-1727), Leibniz (1646-1716)
- Mechanization: Charles Babbage (1791-1871)

# Historical Background

- Polynomial Interpolation: Newton (1642-1727)
- Lagrange Interpolation: Lagrange (1736-1813)
- Other mathematicians: Gauss, Euler, Cholesky, Jacobi, Adams-Bashforth and so on

For detailed history of each topic, please refer the book: H.H. Goldstine, A History of Numerical Analysis from the 16th through the 19th Century, Springer, 1977.



# Numerical Analysis in India



- Sidharacharya (750 AD) solving a quadratic equation
- Approximate value of  $\pi$ , Aryabhat (5th Century)
- Value of  $\pi$ . Madhava of Sagamagrama (14th Century), Later  $\sin x$  and  $\cos x$  series.
- Finding Square root of a number, Brahmagupta (628 CE)



# Prerequisites



# Numerical Analysis: Prerequisites

- Real Analysis
- Riemann Integral
- Linear Algebra
- Differential Equations
- Functional Analysis [For Advanced Topics]



# Numerical Analysis: Keywords

- Error: Roundoff, truncation, bounds
- Stability, sensitive to data
- Ill-posed problem
- Conditioning
- Iteration, algorithm
- Convergence



# Limit



## Definition 1 (Limit)

A function  $f$  defined on a set  $X$  of a real numbers has the limit  $L$  at  $x_0$ , written as

$$\lim_{x \rightarrow x_0} f(x) = L$$

if, for any given real number  $\epsilon > 0$ , there exists a real number  $\delta > 0$  such that

$$|f(x) - L| < \epsilon, \quad \text{whenever } x \in X \quad \text{and} \quad 0 < |x - x_0| < \delta$$

# Continuous

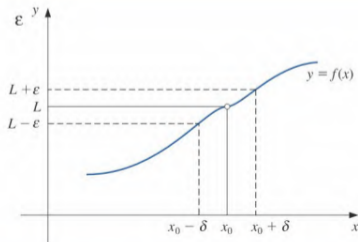


## Definition 2 (Continuous)

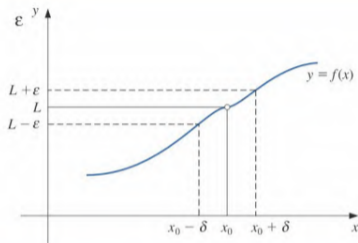
Let  $f$  be a function defined on a set  $X$  of real numbers and  $x_0 \in X$ . Then  $f$  is continuous at  $x_0$  if

$$\lim_{x \rightarrow x_0} f(x) = f(x_0)$$

The function is continuous on the set  $X$  if it is continuous at each number in  $X$ .



# Set of all Continuous functions



Remarks:

1. The set of all functions that are continuous on a set  $X$  is denoted by  $C(X)$ .
2. The set of all functions that are continuous at every real number is denoted by  $C(\mathbb{R})$ .

# Convergent Sequence



## Definition 3

Let  $\{x_n\}_{n=1}^{\infty}$  be an infinite sequence of real numbers. This sequence has the limit  $x$  or converges to  $x$  if, for any  $\epsilon > 0$ , there exists a positive integer  $N(\epsilon)$  such that  $|x_n - x| < \epsilon$  whenever  $n > N(\epsilon)$ .

$$\lim_{n \rightarrow \infty} x_n = x$$

means that the sequence converges to  $x$ .

# Convergent Sequence



## Example 4

$$\lim_{n \rightarrow \infty} \frac{n+1}{n} = 1$$
$$\lim_{n \rightarrow \infty} \left( \frac{n+1}{n} \right)^n = e$$

# Theorem



## Theorem 5

If  $f$  is a function defined on a set  $X$  of real numbers and  $x_0 \in X$ , then the following statements are equivalent

1.  $f$  is continuous at  $x_0$
2. If  $\{x_n\}_{n=1}^{\infty}$  is any sequence in  $X$  converging to  $x_0$ , then

$$\lim_{n \rightarrow \infty} f(x_n) = f(x_0)$$



# Differentiable

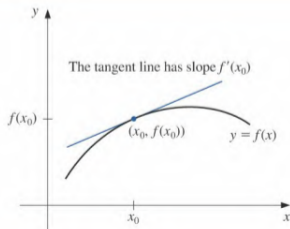


## Definition 6 (Derivative)

Let  $f$  be a function defined in an open interval containing  $x_0$ . The function  $f$  is differentiable at  $x_0$  if

$$f'(x_0) = \lim_{x \rightarrow x_0} \frac{f(x) - f(x_0)}{x - x_0}$$

exists. The number  $f'(x_0)$  is called the derivative of  $f$  at  $x_0$ . A function that has a derivative at each number in a set  $X$  is differentiable on  $X$ .



Source: Thomas Calculus Book

# Theorem and Remarks



## Theorem 7

If the function  $f$  is differentiable at  $x_0$ , then  $f$  is continuous at  $x_0$ .

## Remark:

1. The set of all functions that have  $n$  continuous derivatives on a set  $X$  is denoted by  $C^n(X)$ .
2. The set of all functions that have continuous derivatives of all order at every real number is denoted by  $C^\infty(\mathbb{R})$ .
3.  $C^1(\mathbb{R}) \subset C(\mathbb{R})$ . Example,  $|x| \in C(\mathbb{R})$ ,  $|x| \notin C^1(\mathbb{R})$ .
4.  $C^\infty(\mathbb{R}) \cdots \subset C^2(\mathbb{R}) \subset C^1(\mathbb{R}) \subset C(\mathbb{R})$ . Example:  $e^x \in C^\infty(\mathbb{R})$ .

# Thanks

**Doubts and Suggestions**

[panch.m@iittp.ac.in](mailto:panch.m@iittp.ac.in)



# MA633L-Numerical Analysis

Lecture 1 : Introduction - What? Why? How?

**Panchatcharam Mariappan<sup>1</sup>**

<sup>1</sup>Associate Professor  
Department of Mathematics and Statistics  
IIT Tirupati, Tirupati

**January 9, 2025**

