

## Projeto Computacional 1 - Cálculo Numérico

### Turma IC - 2º Semestre 2025

Integrantes:

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## **Explicações:**

**1) Implementações:** bissecção, newton, secante implementados em `metodos_raizes.py`. Limita o tamanho do passo quando o método original produz passos grandes, evitando overflow.

**2) Exercício I:** para cada função foram produzidas tabelas e gráficos. Ver páginas com tabelas geradas.

**3) Exercício II:** provar a existência de raiz em  $[0,1]$  via avaliação em 0 e 1.

**4) Casos de falha e mitigação:** os runs originais de Newton para  $f_3$   $x_0=1.45$  e  $ex_2$   $x_0=0.7$  divergira

**5) O que cada integrante fez:**

- Felipe: Códigos em python
- Gianluca: Realização dos resultados
- Lucas: Organização do PDF

# ex2\_bisection\_0\_1.csv

k	xk	f(xk)	step
1	0.5 0.25 0.125 0.1875	0.1909523064943483	0.5 0.25 0.125 0.0625
2	0.15625 0.171875	0.0614502536579895	0.03125 0.015625
3	0.1796875	-0.0446920620023974	0.0078125 0.00390625
4	0.17578125	0.0112111092372825	0.001953125
5	0.173828125	-0.0161208335851449	0.0009765625
6	0.1748046875	-0.0022877614885285	0.00048828125
7	0.17431640625	0.0045048764094097	0.000244140625
8	0.174560546875	0.0011191841220265	0.0001220703125
9	0.1744384765625	-0.00058165415755	6.103515625e-05
10	0.17449951171875	0.000269426398556	3.0517578125e-05
11	0.174468994140625	-0.000155948872443	1.52587890625e-05
12	0.1744842529296875	5.678005826617594e-05	7.62939453125e-06
13	0.1744918823242187	-4.957408871253399e-05	3.814697265625e-06
14	0.1744956970214843	3.605565049358273e-06	1.9073486328125e-06
15	0.1744937896728515	-2.298361684824335e-05	9.5367431640625e-07
16	0.1744947433471679	9.60864643031536e-06	4.768371562503125e-07
17	0.1744952201843261	-3.0416094813912053e-06	2.384185791015625e-07
18	0.1744954586029052	2.819878630044848e-07	1.1920928955078125e-07
19	0.1744953393936157	-1.3798082894589392e-06	5.960464477539064e-08
20	0.1744953989982605	-5.489095832589275e-07	2.9802322387695312e-08
21	0.1744953691959381	-1.3346070262820753e-07	
22		7.426361953166786e-08	
23		-2.9598531708918685e-08	
24		2.23325463954982e-08	
25		-3.632992018332004e-09	

ex2\_f0\_f1.csv

x	f(x)
0.0	-0.166818569905618
1.0	0.1867348206876557

## ex2\_newton\_x0\_0.3.csv

k	xk	f(xk)	f'(xk)	step
1	0.3	0.0968033434580016	0.6610702414622878	-0.1464342779125445
2	0.1535657220874554	-0.0185291890905583	0.8988986061591835	0.0206132137302225
3	0.1741789358176779	-0.0002757683555618	0.8716969541847347	0.0003163580579672
4	0.1744952938756452	-6.92564725846001e-08	0.8712590185670689	7.94901069701453e-08
5	0.1744953733657522	-4.3853809472693675e-15	0.8712589084535288	5.033384341576894e-15

ex2\_newton\_x0\_0.7\_error.csv

error
Newton step too large: -721334071.9305339

ex2\_newton\_x0\_0.7\_safe\_error.csv

error
name 'newton_safe' is not defined

# ex2\_secant\_0.3\_0.6.csv

k	xk	f(xk)	step
1	0.3                  0.6	0.0968033434580016	
2	0.0467732514685228	0.211487132614622	0.3
3	0.2472552150750116	-0.1201983911203722	-0.5532267485314771
4	0.1809633402191776	0.0593797707133972	0.2004819636064887
5	0.1740522657405911	0.0056060312002854	0.066291074055034
6	0.1744976824615919	-0.0003861973721281	-0.0069110744785864
7	0.1744953741783528	2.011816623459506e-06	0.0004454167210008
8		7.079812014421093e-10	-2.3082832391330133e-06



## ex2\_summary\_roots.csv

method	root	f(root)	niter
bisection	0.1744953691959381	-3.632992018332004e-09	25.0
newton_0.3	0.1744953733657522	-4.3853809472693675e-15	5.0
secant	0.1744953741783528	7.079812014421093e-10	8.0
<del>newton_0.7_epsilon=4</del>			

newton\_f1\_x0\_0.5.csv

k	xk	f(xk)	f'(xk)	step
1	0.5 -0.5	0.3032653298563167	0.3032653298563167	-1.0 0.3333333333333333
2	-0.16666666666666666	-0.8243606353500641	2.4730819060501923	0.1428571428571428
3	-0.0238095238095238	-0.1968934021442743	1.3782538150099206	0.0232558139534884
4	-0.0005537098560354	-0.0243832198464995	1.0484784533994782	0.0005534034311012
5	-3.0642493416461764e-07	-0.000554016535538	1.0011078797171735	3.0642484026840615e-07
6	-9.389621148813321e-14	-3.064250280608724e-07	1.0000006128500092	9.38962114881244e-14
7		-9.389621148814204e-14	1.00000000000001878	

newton\_f1\_x0\_2.csv

[illegible]

2	-133.2168379446635	-2364032.4930259543	53239.17773592421	44.40400084223644
3	-88.81283710242705	-700444.9816682754	23662.16010254673	29.601903572315333
4	-59.21093353011172	-207533.4525593626	10516.803948521923	19.73350968366489
5	-39.477423046446025	-61407.704631303904	4674.400900656025	13.154152775030962
6	-26.323271071415864	-18216.45557141793	2077.743799697718	8.767421456903474
7				5.842526227442412
8	-17.55584961451239	-5396.294914844378	923.6235670621244	3.892729453600776
9	-11.713323387069975	-1598.377425039797	410.6058343102415	2.594733628466411
10	-7.820593933469201	-473.5001437136647	182.48506841664584	1.7359740236629102
11	-5.22506030500279	-140.490377514009	80.92004770221156	1.1022444507133330
12	-3.48988628133988	-42.0145075400996	35.53791877005288	0.8668106289229122
13	-2.307641822626546	-12.9810372911458	14.9756323446055	0.8703788767137313
14	-1.4408311937036338	-4.550326481276632	5.227983586248314	-110.10150833329126
15	-0.5704523169899025	-2.615181906322723	-0.0237524621225554	36.88872720569177
16	-110.67196065028116	-1355433.8083238218	36743.84862253215	24.591582839170204
17	-73.7032334445094	-401602.5960070705	16330.096612616329	16.393112070704927
18	-49.1916506054192	-118988.67400286705	7258.455467856917	10.92699858306116
19	-32.79853852671427	-35253.03673738396	3226.2323884650805	7.28243780730174
20	-21.871539943653104	-10443.691469475652	1434.09277852044	4.852483775783422
21	-14.589102136351364	-3093.5831325616778	637.5257034346758	3.23322112355597
22	-9.736618360567942	-916.311715694686	283.40521129804625	2.157189201753768
23	-6.503397237011972	-271.5524276472404	125.00252606712400	1.4505777606225045
24	-4.346208035258204	-80.75159419764293	55.66857285722894	1.0094917301340562
25	-2.89563026663562	-24.38328739989907	24.15402392316881	0.8088693994090237
26	-1.886138536501564	-7.823834349437229	9.672555736628782	1.2786127094042514
27	-1.07726913709254	-3.17291116971955	2.481526381196317	-3.635297827131484
28	0.2013435723117114	-3.193181258096973	-0.878382297666276	1.1653255679536882
29	-3.4339542540197723	-40.05937794030673	34.376125472504455	-0.0592274261519001
30	-2.268628686866084	-12.40726839841493	14.4400283566152	0.8852674936108347
31	-1.409401260714184	-4.3902501947561205	4.959235741108193	-14.898115868089404
32	-0.5241337671033492	-2.619854272736351	-0.1758513825461563	5.1305307653333
33	-15.422249635192752	-3655.6948029638447	712.537351430609	3.4183833966127866
34	-10.291718869859452	-1082.801764305309	316.7584318886633	2.2798687089193947
35	-6.073335473246665	-320.0410600490060	140.72022150337209	1.5301554056771031
36	-4.59346676432727	-95.32839218403194	62.29981074493773	1.0563794749071107
37	-3.063311358650087	-28.68242405080943	27.151629440103925	0.8189363679833422
38	-2.0069318837429764	-9.076539360330129	11.083326757952396	1.0787452475676862
39	-1.187995515759634	-3.488662169894827	3.2340000363949963	-2.999454768484019
40	-0.1092502681919478	-2.892053701614266	-0.9641931366999624	1.0693703831512869
41	-3.1007050366759660	-29.933966562610323	27.99214101516357	-0.0227156163005340
42	-2.03933465352468	-9.44202533774361	11.47665748719988	1.0417639995953594
43	-1.216619037216145	-3.584174086242112	3.4404856451502184	-3.116329677475897
44	-0.1748550376207855	-2.830491029989976	-0.9082771474559008	1.1226484645134394
45	-3.291184715096682	-35.358588563637255	31.4956904866581	0.8414257386416629
46	-2.1685362505832435	-11.02911274547582	13.107648410280897	0.9361666520098808
47	-1.3271105119415005	-4.010226130727600	4.203666932717532	-4.928647431504603
48	-0.3909438599316995	-2.6688068665157307	-0.541488695145111	1.7666841976783323
	-5.319591291436303	-148.2144770747372	83.89415452377484	

# newton\_f2\_x0\_0.62.csv

k	xk	f(xk)	f'(xk)	step
1	0.62	-3.381672	0.1532	22.073577023498693
2	22.69357702349869	11661.463145467556	1543.9953143644036	-7.552784025298728
3	15.140792998199966	3452.7892917550816	686.7308378430233	-5.02786405020061
4	10.112928947999356	1021.1497840476172	305.8139957218501	-3.339120505708945
5	6.773808442290413	301.03887505787065	136.65344243853465	-2.202936638008772
6	4.570871804281642	87.92775425229144	61.67860715353073	-1.4255794401034574
7	3.145292364178184	24.970657411507105	28.67859216847277	-0.8707072252646381
8	2.274585138913546	6.4935214144321645	14.521212662499067	-0.4471748720547037
9	1.8274102668588423	1.275095263703686	9.018284850263315	-0.1413899965320407
10	1.6860202703268017	0.1067694488011241	7.527993055858584	-0.0141829898100174
11	1.6718372805167845	0.0010146123394019	7.38511967757727	-0.0001373860389131
12	1.6716998944778712	9.466481065700805e-08	7.383741611591976	-1.2820710100200512e-08
13	1.671699881657161	8.881784197001252e-16	7.383741482997699	-1.202883960313758e-16

newton\_f3\_x0\_1.0.csv

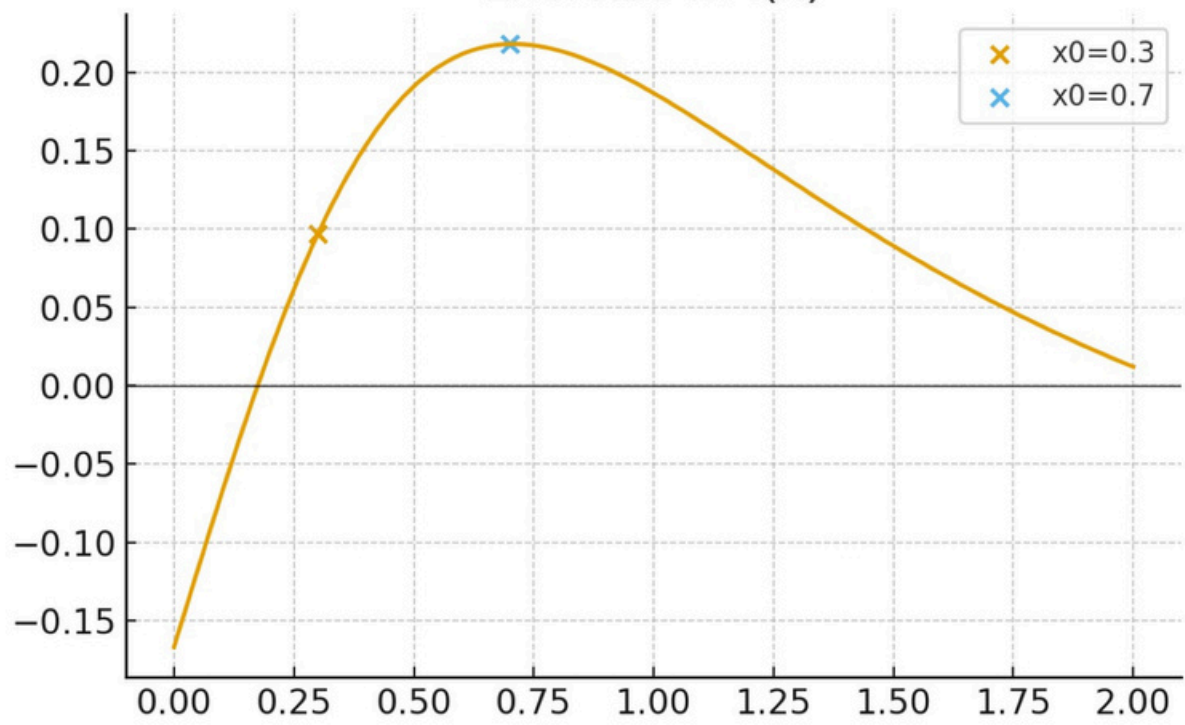
k	xk	f(xk)	f'(xk)	step
1	1.0	0.7853981633974483	0.5	-1.5707963267948966
2	-0.5707963267948966	-0.5186693692550166	0.7542567725392094	0.6876562307938097
3	0.1168599039989131	0.1163322651138959	0.9865277431717276	-0.1179209261159578
4	-0.0010610221170447	-0.00106102171889	0.9999988742333344	0.0010610229133543
5	7.963096044106415e-10	7.963096044106415e-10	1.0	-7.963096044106415e-10

newton\_f3\_x0\_1.45\_error.csv

error
Newton step too large: -416375105.2821845

ex2\_function.png

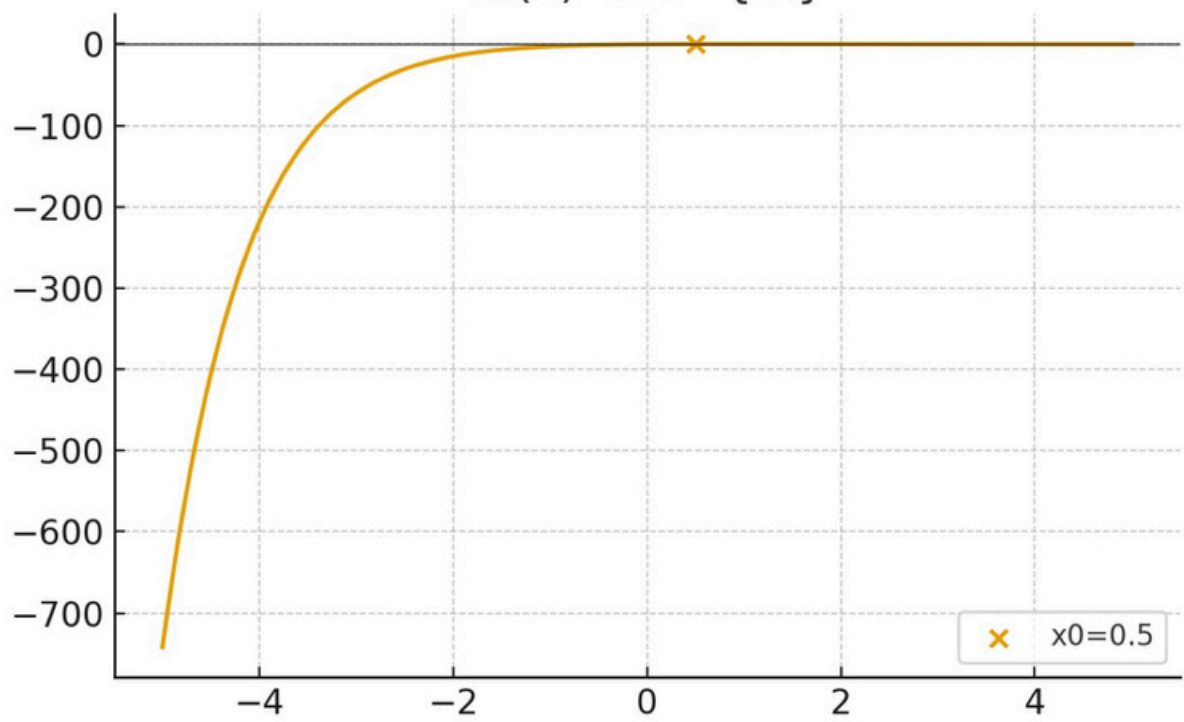
Exercise II:  $f(x)$





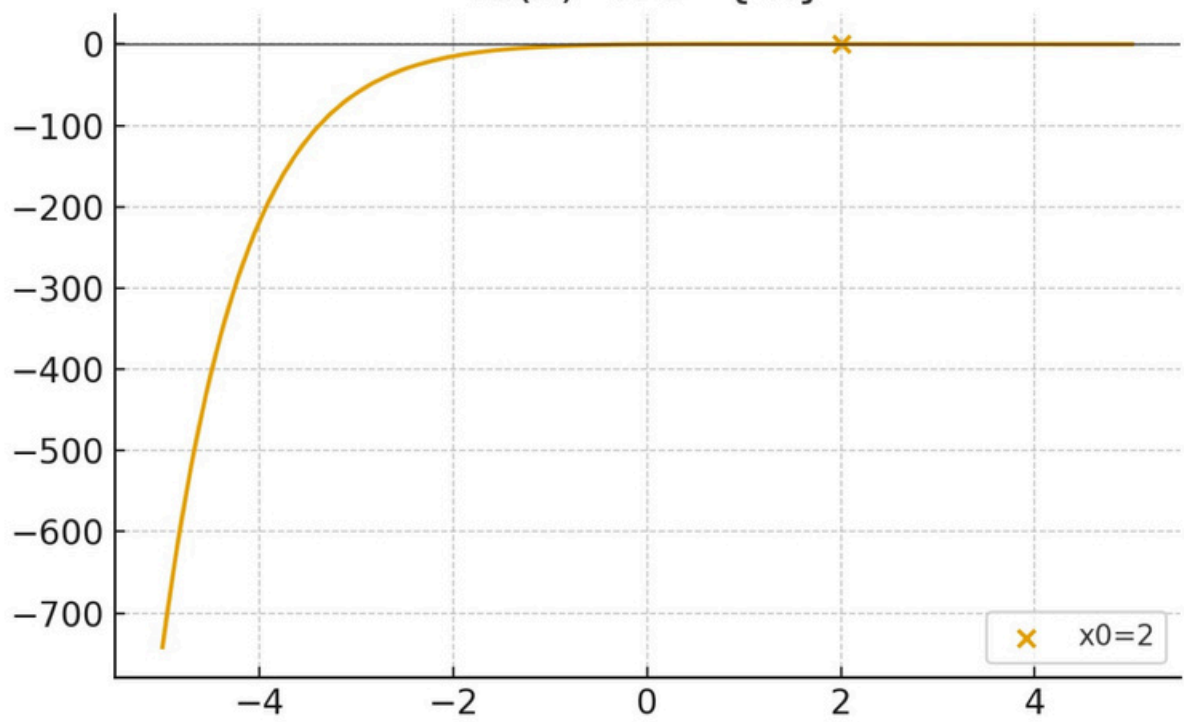
f1\_x0\_0.5.png

$$f1(x) = x e^{-x}$$



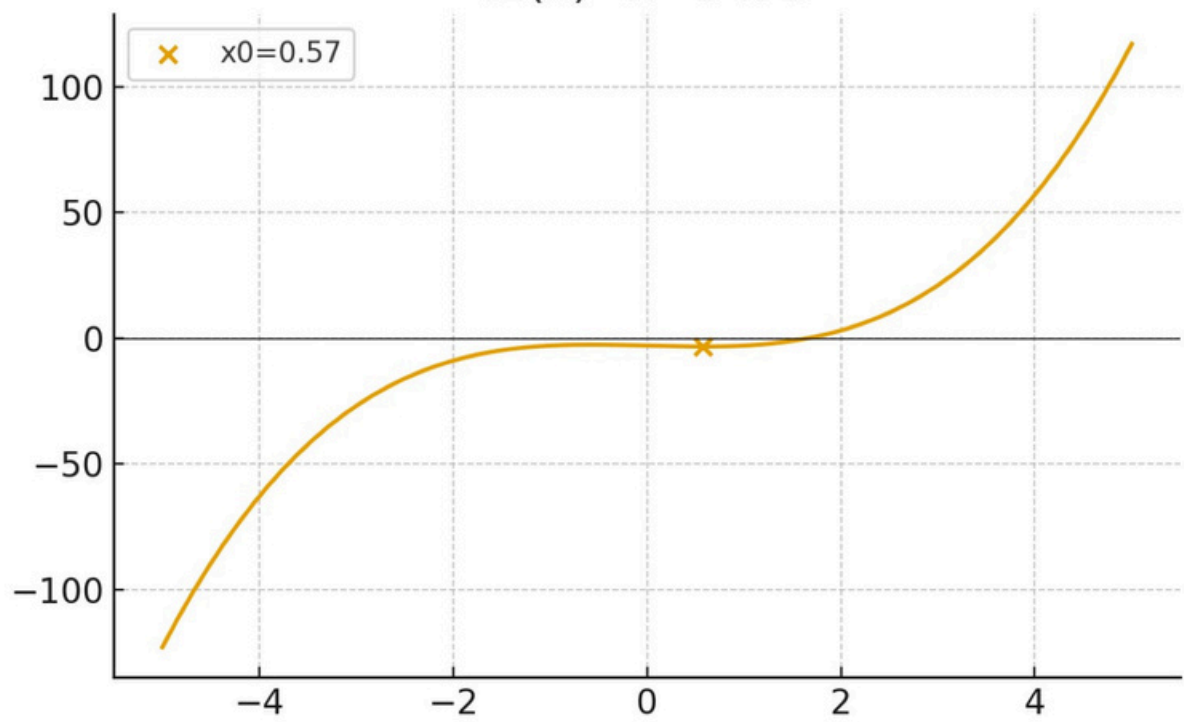
f1\_x0\_2.png

$$f1(x) = x e^{-x}$$



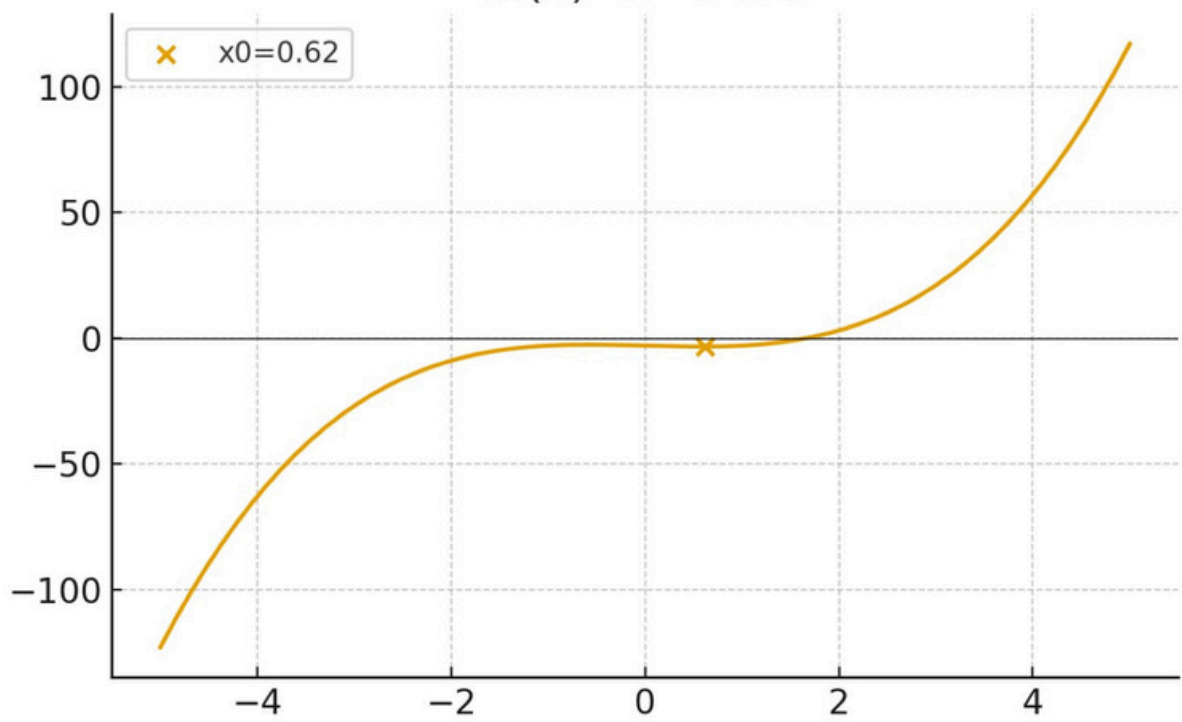
f2\_x0\_0.57.png

$$f_2(x) = x^3 - x - 3$$



f2\_x0\_0.62.png

$$f_2(x) = x^3 - x - 3$$



f3\_x0\_1.0.png

$$f_3(x) = \operatorname{arctg}(x)$$

