

AE/ME 5830 Spring 2021 Homework I, Due: Thursday, February 11 by 5:00 pm

1. The non-dimensional displacement of an airplane wing tip ($f(t)$) obtained from an aeroelastic flutter study is represented by

$$f(t) = 2\sin(t^2) - 3t\sin(t^2) + t^2\sin(t^2)$$

where t is the non-dimensional time.

- (a) For three different starting points $t_0 = 2.2$, $t_0 = 2.3$, and $t_0 = 2.4$, find the roots of $f(t)$ (non-dimensional times at which the displacement is equal to zero) using Newton's Method. For each case, tabulate t_n , $f(t_n)$, $\Delta_n t = t_{n+1} - t_n$, and t_{n+1} at each iteration level n . Use a convergence criterion of $(\epsilon_n)_r < 10^{-8}$ where $(\epsilon_n)_r = \frac{|t_{n+1} - t_n|}{|t_n|}$.
 - (b) Use the method of linear interpolation (Regula-Falsi) to find the root of $f(t) = 0$ for $3.2 \leq t \leq 3.8$ with the same convergence criterion given in part (a). Tabulate t_{n+1} , $f(t_{n+1})$, and $(\epsilon_n)_r$ at each iteration level n .
2. The free vibrations of a cantilever beam satisfy the equation

$$\cosh(\alpha) \times \cos(\alpha) = -1$$

where the dimensionless parameter α is proportional to the square root of the natural frequency. Using Secant Method, find the three smallest positive values of α satisfying this equation (pick the appropriate initial guesses for finding each root). For each root: (1) use a convergence criterion of $(\epsilon_n)_r = \frac{|\alpha_{n+1} - \alpha_n|}{|\alpha_n|} < 10^{-6}$, (2) tabulate the values of α_n , $f(\alpha_n)$, $\Delta_n \alpha = \alpha_{n+1} - \alpha_n$, and α_{n+1} at each iteration.

3. For $-1.0 \leq x \leq 0.0$, find the root of the function

$$f(x) = e^{6x} + 3(\ln 2)^2 e^{2x} - e^{4x} \ln 8 - (\ln 2)^3 = 0$$

- (a) Use Newton's Method with a starting point of $x_0 = -1.0$.
- (b) Use Modified Newton's Method with a starting point of $x_0 = -1.0$.

For each method: (1) approximate the root with a convergence criterion of $(\epsilon_n)_r = \frac{|x_{n+1} - x_n|}{|x_n|} < 10^{-5}$, (2) tabulate the values of x_n , $f(x_n)$, $\Delta_n x = x_{n+1} - x_n$, and x_{n+1} at each iteration, and (3) plot $|f(x_n)|/|f(x_0)|$ vs. iteration number on a semi-log plot. Comment on the convergence of each method.

4. (Modified from problem 8.35 in the textbook) Mechanical and Aerospace engineers use thermodynamics extensively in their work. The following polynomial (curve-fit) can be used to relate the specific heat at constant pressure of dry air, c_p (kJ/kgK) to temperature T for a range of values:

$$c_p = 0.99403 + 1.671 \times 10^{-4}T + 9.7215 \times 10^{-8}T^2 \\ - 9.5838 \times 10^{-11}T^3 + 1.9520 \times 10^{-14}T^4$$

Use a fixed point iteration scheme to determine the temperature that corresponds to specific heat of 1.2 (kJ/kgK) with a convergence criterion of $(\epsilon_n)_r = \frac{|T_{n+1} - T_n|}{|T_n|} < 10^{-5}$. Show the derivation of the fixed-point function $g(T)$ used in your scheme. Solve the problem with two different initial guesses, $T_0 = 500 K$ and $T_0 = 2000 K$. For each case, tabulate the values of T_n , T_{n+1} , and $(\epsilon_n)_r$ at each iteration level n and limit the maximum number of iterations to $N_{max} = 100$.

1a)

initial guess = some #

tol = some #

n = 0

while $\epsilon_n > tol$

$$\left\{ \begin{array}{l} t_{n+1} = t_n - \frac{f(t_n)}{f'(t_n)} \\ n = n + 1 \end{array} \right.$$

$$t_0 = 2.2, 2.3, 2.4 \quad tol = 10^{-8}$$

$t_0 = 2.2$ converges to zero with 538 iter.

$t_0 = 2.3$ converges to zero with 540 iter.

$t_0 = 2.4$ converges to 2.5 with 5 iter.

q1a t_0 = 2.2

iteration (n)	t_n	f(t)	t_n+1 - t_n
0	2.2	-3.8087760280739045	-1.720350208122199
1	0.4796497918778011	-0.17557604024986012	-0.35088529526559986
2	0.12876449661220124	-0.01630464232083959	-0.0654924417121676
3	0.06327205490003364	-0.003987315445886372	-0.0317638702451786
4	0.03150818465485504	-0.0009917799535951435	-0.015769768751627382
5	0.015738415903227658	-0.0002476363784427203	-0.007871158263712843
6	0.007867257639514815	-6.188991189159556e-05	-0.003933872321933267
7	0.003933385317581548	-1.5471280688016014e-05	-0.001966723087614171
8	0.001966662229967377	-3.8677453672006665e-06	-0.000983334918307087
9	0.0009833273116602898	-9.669316668982455e-07	-0.0004916641312368355
10	0.0004916631804234543	-2.4173262454941386e-07	-0.0002458316496372906
11	0.00024583153078616373	-6.043313787650393e-08	-0.00012291577282126873
12	0.000122915757964895	-1.5108283327824418e-08	-6.14578799109706e-05
13	6.14578780539244e-05	-3.777070760624779e-09	-3.072893914302758e-05
14	3.072893891089682e-05	-9.44267685697987e-10	-1.536446946995658e-05
15	1.536446944094024e-05	-2.360669211458589e-10	-7.682234722283641e-06
16	7.682234718656599e-06	-5.901673026904986e-11	-3.84111735955499e-06
17	3.841117359101609e-06	-1.475418256617403e-11	-1.9205586795791406e-06
18	1.920558679522468e-06	-3.688545641475481e-12	-9.602793397647762e-07
19	9.60279339757692e-07	-9.221364103646184e-13	-4.801396698792887e-07
20	4.801396698784033e-07	-2.3053410259088894e-13	-2.40069834939257e-07
21	2.4006983493914634e-07	-5.763352564770565e-14	-1.200349174695801e-07
22	1.2003491746956623e-07	-1.4408381411925368e-14	-6.001745873478398e-08
23	6.001745873478226e-08	-3.602095352981278e-15	-3.000872936739124e-08
24	3.0008729367391016e-08	-9.005238382453152e-16	-1.500436468369552e-08
25	1.5004364683695495e-08	-2.2513095956132855e-16	-7.502182341847749e-09
26	7.502182341847746e-09	-5.628273989033212e-17	-3.751091170923874e-09
27	3.751091170923872e-09	-1.4070684972583025e-17	-1.875545585461936e-09
28	1.875545585461936e-09	-3.517671243145756e-18	-9.37772792730968e-10
29	9.37772792730968e-10	-8.79417810786439e-19	-4.68886396365484e-10
30	4.68886396365484e-10	-2.1985445269660977e-19	-2.34443198182742e-10
31	2.34443198182742e-10	-5.496361317415244e-20	-1.17221599091371e-10
32	1.17221599091371e-10	-1.374090329353811e-20	-5.86107995456855e-11
33	5.86107995456855e-11	-3.4352258233845276e-21	-2.930539977284275e-11
34	2.930539977284275e-11	-8.588064558461319e-22	-1.4652699886421375e-11
35	1.4652699886421375e-11	-2.1470161396153297e-22	-7.326349943210687e-12
36	7.326349943210687e-12	-5.367540349038324e-23	-3.663174971605344e-12
37	3.663174971605344e-12	-1.341885087259581e-23	-1.831587485802672e-12
38	1.831587485802672e-12	-3.354712718148953e-24	-9.15793742901336e-13
39	9.15793742901336e-13	-8.386781795372382e-25	-4.57896871450668e-13
40	4.57896871450668e-13	-2.0966954488430955e-25	-2.28948435725334e-13
41	2.28948435725334e-13	-5.241738622107739e-26	-1.14474217862667e-13
42	1.14474217862667e-13	-1.3104346555269347e-26	-5.72371089313335e-14
43	5.72371089313335e-14	-3.276086638817337e-27	-2.861855446566675e-14
44	2.861855446566675e-14	-8.190216597043342e-28	-1.4309277232833374e-14
45	1.4309277232833374e-14	-2.0475541492608354e-28	-7.154638616416687e-15

46	7.154638616416687e-15	-5.118885373152089e-29	-3.5773193082083435e-15
47	3.5773193082083435e-15	-1.279721343288022e-29	-1.7886596541041717e-15
48	1.7886596541041717e-15	-3.199303358220055e-30	-8.943298270520859e-16
49	8.943298270520859e-16	-7.998258395550138e-31	-4.471649135260429e-16
50	4.471649135260429e-16	-1.9995645988875346e-31	-2.2358245676302147e-16
51	2.2358245676302147e-16	-4.998911497218836e-32	-1.1179122838151073e-16
52	1.1179122838151073e-16	-1.249727874304709e-32	-5.589561419075537e-17
53	5.589561419075537e-17	-3.124319685761773e-33	-2.7947807095377684e-17
54	2.7947807095377684e-17	-7.810799214404432e-34	-1.3973903547688842e-17
55	1.3973903547688842e-17	-1.952699803601108e-34	-6.986951773844421e-18
56	6.986951773844421e-18	-4.88174950900277e-35	-3.4934758869222104e-18
57	3.4934758869222104e-18	-1.2204373772506925e-35	-1.7467379434611052e-18
58	1.7467379434611052e-18	-3.051093443126731e-36	-8.733689717305526e-19
59	8.733689717305526e-19	-7.627733607816828e-37	-4.366844858652763e-19
60	4.366844858652763e-19	-1.906933401954207e-37	-2.1834224293263815e-19
61	2.1834224293263815e-19	-4.767333504885518e-38	-1.0917112146631908e-19
62	1.0917112146631908e-19	-1.1918333762213794e-38	-5.458556073315954e-20
63	5.458556073315954e-20	-2.9795834405534485e-39	-2.729278036657977e-20
64	2.729278036657977e-20	-7.448958601383621e-40	-1.3646390183289885e-20
65	1.3646390183289885e-20	-1.8622396503459053e-40	-6.823195091644942e-21
66	6.823195091644942e-21	-4.655599125864763e-41	-3.411597545822471e-21
67	3.411597545822471e-21	-1.1638997814661908e-41	-1.7057987729112356e-21
68	1.7057987729112356e-21	-2.909749453665477e-42	-8.528993864556178e-22
69	8.528993864556178e-22	-7.274373634163693e-43	-4.264496932278089e-22
70	4.264496932278089e-22	-1.818593408540923e-43	-2.1322484661390445e-22
71	2.1322484661390445e-22	-4.546483521352308e-44	-1.0661242330695222e-22
72	1.0661242330695222e-22	-1.136620880338077e-44	-5.330621165347611e-23
73	5.330621165347611e-23	-2.8415522008451924e-45	-2.6653105826738056e-23
74	2.6653105826738056e-23	-7.103880502112981e-46	-1.3326552913369028e-23
75	1.3326552913369028e-23	-1.7759701255282452e-46	-6.663276456684514e-24
76	6.663276456684514e-24	-4.439925313820613e-47	-3.331638228342257e-24
77	3.331638228342257e-24	-1.1099813284551533e-47	-1.6658191141711285e-24
78	1.6658191141711285e-24	-2.774953321137883e-48	-8.329095570855642e-25
79	8.329095570855642e-25	-6.937383302844708e-49	-4.164547785427821e-25
80	4.164547785427821e-25	-1.734345825711177e-49	-2.0822738927139106e-25
81	2.0822738927139106e-25	-4.3358645642779425e-50	-1.0411369463569553e-25
82	1.0411369463569553e-25	-1.0839661410694856e-50	-5.205684731784777e-26
83	5.205684731784777e-26	-2.709915352673714e-51	-2.602842365892388e-26
84	2.602842365892388e-26	-6.774788381684285e-52	-1.301421182946194e-26
85	1.301421182946194e-26	-1.6936970954210713e-52	-6.50710591473097e-27
86	6.50710591473097e-27	-4.234242738552678e-53	-3.253552957365485e-27
87	3.253552957365485e-27	-1.0585606846381696e-53	-1.6267764786827427e-27
88	1.6267764786827427e-27	-2.646401711595424e-54	-8.133882393413713e-28
89	8.133882393413713e-28	-6.61600427898856e-55	-4.066941196706857e-28
90	4.066941196706857e-28	-1.65400106974714e-55	-2.0334705983534283e-28
91	2.0334705983534283e-28	-4.13500267436785e-56	-1.0167352991767142e-28
92	1.0167352991767142e-28	-1.0337506685919625e-56	-5.083676495883571e-29

93	5.083676495883571e-29	-2.584376671479906e-57	-2.5418382479417854e-29
94	2.5418382479417854e-29	-6.460941678699765e-58	-1.2709191239708927e-29
95	1.2709191239708927e-29	-1.6152354196749413e-58	-6.354595619854464e-30
96	6.354595619854464e-30	-4.038088549187353e-59	-3.177297809927232e-30
97	3.177297809927232e-30	-1.0095221372968383e-59	-1.588648904963616e-30
98	1.588648904963616e-30	-2.523805343242096e-60	-7.94324452481808e-31
99	7.94324452481808e-31	-6.30951335810524e-61	-3.97162226240904e-31
100	3.97162226240904e-31	-1.57737833952631e-61	-1.98581113120452e-31
101	1.98581113120452e-31	-3.943445848815775e-62	-9.9290556560226e-32
102	9.9290556560226e-32	-9.858614622039437e-63	-4.9645278280113e-32
103	4.9645278280113e-32	-2.464653655509859e-63	-2.48226391400565e-32
104	2.48226391400565e-32	-6.161634138774648e-64	-1.241131957002825e-32
105	1.241131957002825e-32	-1.540408534693662e-64	-6.205659785014125e-33
106	6.205659785014125e-33	-3.851021336734155e-65	-3.102829892507062e-33
107	3.102829892507062e-33	-9.627553341835388e-66	-1.551414946253531e-33
108	1.551414946253531e-33	-2.406888335458847e-66	-7.757074731267656e-34
109	7.757074731267656e-34	-6.017220838647117e-67	-3.878537365633828e-34
110	3.878537365633828e-34	-1.5043052096617793e-67	-1.939268682816914e-34
111	1.939268682816914e-34	-3.760763024154448e-68	-9.69634341408457e-35
112	9.69634341408457e-35	-9.40190756038612e-69	-4.848171707042285e-35
113	4.848171707042285e-35	-2.35047689009653e-69	-2.4240858535211424e-35
114	2.4240858535211424e-35	-5.876192225241325e-70	-1.2120429267605712e-35
115	1.2120429267605712e-35	-1.4690480563103314e-70	-6.060214633802856e-36
116	6.060214633802856e-36	-3.672620140775828e-71	-3.030107316901428e-36
117	3.030107316901428e-36	-9.18155035193957e-72	-1.515053658450714e-36
118	1.515053658450714e-36	-2.2953875879848927e-72	-7.57526829225357e-37
119	7.57526829225357e-37	-5.738468969962232e-73	-3.787634146126785e-37
120	3.787634146126785e-37	-1.434617242490558e-73	-1.8938170730633925e-37
121	1.8938170730633925e-37	-3.586543106226395e-74	-9.469085365316962e-38
122	9.469085365316962e-38	-8.966357765565987e-75	-4.734542682658481e-38
123	4.734542682658481e-38	-2.241589441391497e-75	-2.3672713413292406e-38
124	2.3672713413292406e-38	-5.603973603478742e-76	-1.1836356706646203e-38
125	1.1836356706646203e-38	-1.4009934008696855e-76	-5.918178353323102e-39
126	5.918178353323102e-39	-3.502483502174214e-77	-2.959089176661551e-39
127	2.959089176661551e-39	-8.756208755435534e-78	-1.4795445883307754e-39
128	1.4795445883307754e-39	-2.1890521888588836e-78	-7.397722941653877e-40
129	7.397722941653877e-40	-5.472630472147209e-79	-3.6988614708269385e-40
130	3.6988614708269385e-40	-1.3681576180368023e-79	-1.8494307354134692e-40
131	1.8494307354134692e-40	-3.420394045092006e-80	-9.247153677067346e-41
132	9.247153677067346e-41	-8.550985112730014e-81	-4.623576838533673e-41
133	4.623576838533673e-41	-2.1377462781825035e-81	-2.3117884192668365e-41
134	2.3117884192668365e-41	-5.344365695456259e-82	-1.1558942096334183e-41
135	1.1558942096334183e-41	-1.3360914238640647e-82	-5.779471048167091e-42
136	5.779471048167091e-42	-3.340228559660162e-83	-2.8897355240835457e-42
137	2.8897355240835457e-42	-8.350571399150404e-84	-1.4448677620417728e-42
138	1.4448677620417728e-42	-2.087642849787601e-84	-7.224338810208864e-43
139	7.224338810208864e-43	-5.219107124469003e-85	-3.612169405104432e-43

140	3.612169405104432e-43	-1.3047767811172507e-85	-1.806084702552216e-43
141	1.806084702552216e-43	-3.261941952793127e-86	-9.03042351276108e-44
142	9.03042351276108e-44	-8.154854881982817e-87	-4.51521175638054e-44
143	4.51521175638054e-44	-2.038713720495704e-87	-2.25760587819027e-44
144	2.25760587819027e-44	-5.09678430123926e-88	-1.128802939095135e-44
145	1.128802939095135e-44	-1.274196075309815e-88	-5.644014695475675e-45
146	5.644014695475675e-45	-3.185490188274538e-89	-2.8220073477378376e-45
147	2.8220073477378376e-45	-7.963725470686345e-90	-1.4110036738689188e-45
148	1.4110036738689188e-45	-1.990931367671586e-90	-7.055018369344594e-46
149	7.055018369344594e-46	-4.977328419178965e-91	-3.527509184672297e-46
150	3.527509184672297e-46	-1.2443321047947413e-91	-1.7637545923361485e-46
151	1.7637545923361485e-46	-3.110830261986853e-92	-8.818772961680742e-47
152	8.818772961680742e-47	-7.777075654967133e-93	-4.409386480840371e-47
153	4.409386480840371e-47	-1.9442689137417833e-93	-2.2046932404201856e-47
154	2.2046932404201856e-47	-4.860672284354458e-94	-1.1023466202100928e-47
155	1.1023466202100928e-47	-1.2151680710886146e-94	-5.511733101050464e-48
156	5.511733101050464e-48	-3.0379201777215365e-95	-2.755866550525232e-48
157	2.755866550525232e-48	-7.594800444303841e-96	-1.377933275262616e-48
158	1.377933275262616e-48	-1.8987001110759603e-96	-6.88966637631308e-49
159	6.88966637631308e-49	-4.746750277689901e-97	-3.44483318815654e-49
160	3.44483318815654e-49	-1.1866875694224752e-97	-1.72241659407827e-49
161	1.72241659407827e-49	-2.966718923556188e-98	-8.61208297039135e-50
162	8.61208297039135e-50	-7.41679730889047e-99	-4.306041485195675e-50
163	4.306041485195675e-50	-1.8541993272226175e-99	-2.1530207425978375e-50
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539

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388	-6.0161409966392936e-117	-3.6193952491444033e-233	3.0080704983196468e-117
389	-3.0080704983196468e-117	-9.048488122861008e-234	1.5040352491598234e-117
390	-1.5040352491598234e-117	-2.262122030715252e-234	7.520176245799117e-118
391	-7.520176245799117e-118	-5.65530507678813e-235	3.7600881228995585e-118
392	-3.7600881228995585e-118	-1.4138262691970325e-235	1.8800440614497793e-118
393	-1.8800440614497793e-118	-3.5345656729925813e-236	9.400220307248896e-119
394	-9.400220307248896e-119	-8.836414182481453e-237	4.700110153624448e-119
395	-4.700110153624448e-119	-2.2091035456203633e-237	2.350055076812224e-119
396	-2.350055076812224e-119	-5.522758864050908e-238	1.175027538406112e-119
397	-1.175027538406112e-119	-1.380689716012727e-238	5.87513769203056e-120
398	-5.87513769203056e-120	-3.4517242900318177e-239	2.93756884601528e-120
399	-2.93756884601528e-120	-8.629310725079544e-240	1.46878442300764e-120
400	-1.46878442300764e-120	-2.157327681269886e-240	7.3439221150382e-121
401	-7.3439221150382e-121	-5.393319203174715e-241	3.6719610575191e-121
402	-3.6719610575191e-121	-1.3483298007936788e-241	1.83598052875955e-121
403	-1.83598052875955e-121	-3.370824501984197e-242	9.17990264379775e-122
404	-9.17990264379775e-122	-8.427061254960492e-243	4.589951321898875e-122
405	-4.589951321898875e-122	-2.106765313740123e-243	2.2949756609494376e-122
406	-2.2949756609494376e-122	-5.266913284350308e-244	1.1474878304747188e-122
407	-1.1474878304747188e-122	-1.316728321087577e-244	5.737439152373594e-123
408	-5.737439152373594e-123	-3.2918208027189423e-245	2.868719576186797e-123
409	-2.868719576186797e-123	-8.229552006797356e-246	1.4343597880933985e-123
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412	-3.585899470233496e-124	-1.2858675010620868e-247	1.792949735116748e-124
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415	-4.48237433779187e-125	-2.0091679704095107e-249	2.241187168895935e-125
416	-2.241187168895935e-125	-5.022919926023777e-250	1.1205935844479676e-125
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418	-5.602967922239838e-126	-3.1393249537648605e-251	2.801483961119919e-126
419	-2.801483961119919e-126	-7.848312384412151e-252	1.4007419805599594e-126
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422	-3.5018549513998986e-127	-1.2262988100643986e-253	1.7509274756999493e-127
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426	-2.1886593446249366e-128	-4.790229726814057e-256	1.0943296723124683e-128
427	-1.0943296723124683e-128	-1.1975574317035143e-256	5.4716483615623416e-129
428	-5.4716483615623416e-129	-2.9938935792587857e-257	2.7358241807811708e-129
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434	-8.549450564941159e-131	-7.30931049623727e-261	4.2747252824705794e-131
435	-4.2747252824705794e-131	-1.8273276240593174e-261	2.1373626412352897e-131
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437	-1.0686813206176448e-131	-1.1420797650370734e-262	5.343406603088224e-132
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441	-6.67925825386028e-133	-4.461249082176068e-265	3.33962912693014e-133
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516	-1.767984938824964e-155	-3.1257707439119e-310	8.839924694124826e-156
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518	-4.4199623470623977e-156	-1.9536067149447e-311	2.2099811735309334e-156
519	-2.2099811735314643e-156	-4.884016787363e-312	1.1049905867656134e-156
520	-1.104990586765851e-156	-1.22100419684e-312	5.5249529338218845e-157
521	-5.524952933836625e-157	-3.0525104921e-313	2.762476466929613e-157
522	-2.762476466907012e-157	-7.63127623e-314	1.3812382334481007e-157
523	-1.3812382334589112e-157	-1.907819058e-314	6.906191168107722e-158
524	-6.90619116648139e-158	-4.76954764e-315	3.4530955826719556e-158
525	-3.453095583809435e-158	-1.192386913e-315	1.7265477946285841e-158
526	-1.7265477891808507e-158	-2.98096726e-316	8.632738915222728e-159
527	-8.632738976585779e-159	-7.452418e-317	4.316369370731075e-159
528	-4.316369605854704e-159	-1.8631048e-317	2.158184912742731e-159
529	-2.1581846931119728e-159	-4.65776e-318	1.0790919389628366e-159
530	-1.0790927541491362e-159	-1.164444e-318	5.395474826330213e-160
531	-5.395452715161149e-160	-2.9111e-319	2.697720048292798e-160
532	-2.697732666868351e-160	-7.2776e-320	1.3488339768835789e-160
533	-1.348898689984772e-160	-1.8196e-320	6.7449237928085365e-161
534	-6.744063107039184e-161	-4.55e-321	3.3735928371195196e-161
535	-3.3704702699196642e-161	-1.136e-321	1.6857454515715877e-161
536	-1.6847248183480765e-161	-2.8e-322	8.357964905082983e-162
537	-8.489283278397782e-162	-7.4e-323	4.3649059906370593e-162
538	-4.1243772877607224e-162	-1.5e-323	1.7968736055285565e-162
539	-2.327503682232166e-162	-5e-324	1.0613638328756981e-162
540	-1.2661398493564678e-162	0.0	0.0
541	-1.2661398493564678e-162	0.0	

q1a t_0 = 2.4

iteration (n)	t_n	f(t)	t_{n+1}-t_n	eps
0	2.4	-2.3782953636364557	0.13673559200984675	0.056973
1	2.5367355920098467	0.8220987161758242	-0.029334899218623534	0.011564
2	2.507400692791223	0.02047633955669373	-0.0007717377242539847	0.000308
3	2.506628955066969	1.802201620675752e-05	-6.804354368838972e-07	2.71E-07
4	2.5066282746315323	1.4085324346507245e-11	-5.32018873400375e-13	2.12E-13
5	2.5066282746310002	-5.986418372261646e-15		

1b)

initial guesses

$$a = 3.2$$

$$b = 3.8$$

$$\text{tol} = 10^{-8}$$

$n=0$
While $\epsilon_n > 0$

$$\left\{ \begin{array}{l} c = b - f(a) * f(b) / (f(b) - f(a)) \\ \therefore f(c) f(b) > 0 \end{array} \right.$$

$$\left. \begin{array}{l} \\ \} b = c \end{array} \right.$$

else

$$\left. \begin{array}{l} a = c \\ n = n + 1 \end{array} \right.$$

$$c = 3.54$$

$$n = 8$$

q1b

iteration (n)	t_n	t_n+1	f(n)	eps_n	Initial interval
0	3.2	3.8	-6.725591522	0.1875	3.2-3.8
1	3.8	3.406369685	12.82841858	0.103586925	
2	3.406369685	3.565491201	-8.704481116	0.046712932	
3	3.565491201	3.53938828	1.708125013	0.007320989	
4	3.53938828	3.544837003	-4.51E-01	0.001539453	
5	3.544837003	3.544906865	-5.80E-03	1.97E-05	
6	3.544906865	3.544907692	-6.87E-05	2.33E-07	
7	3.544907692	3.544907702	-8.12E-07	2.76E-09	
8	3.544907702		-9.60908E-09		

2)

$$a_0 = \text{some } \#$$

$$a_1 = \text{some } \#$$

$$\epsilon_{\text{tol}} = 10^{-6}$$

$$n=0$$

while $\epsilon_n > 0$

$$\left| \begin{array}{l} a_{n+1} = a_n - (f(a_n) + f'(a_n)) / (a_{n+1} - a_n) \\ n = n+1 \end{array} \right.$$

root1

1.875

root2

4.69

root3

7.85

q2 root 1

iteration (n)	a_n	a_n+1	f(a)	a_n+1 - a_n	interval
0	0.1	2	1.999983333	1.9	.1-2
1	2	1.581117381	-0.565625835	-0.418882619	
2	1.581117381	1.846097084	1.999983333	0.264979703	
3	1.846097084	1.882453695	-0.565625835	0.036356611	
4	1.882453695	1.874945907	0.973856569	-0.007507788	
5	1.874945907	1.875103218	0.117497038	0.000157312	
6	1.875103218	1.875104069	-0.030578125	8.50E-07	
	1.875104069		0.00065442		

q2 root 2

iteration (n)	a_n	a_n+1	f(a)	a_n+1 - a_n	interval
0	3	4.8	-8.966909834	1.8	3-4.8
1	4.8	4.056084055	6.316379052	-0.743915945	
2	4.056084055	4.595170375	-8.966909834	0.53908632	
3	4.595170375	4.813370669	6.316379052	0.218200294	
4	4.813370669	4.682285321	-16.62393093	-0.131085348	
5	4.682285321	4.692756671	-4.789925709	0.01047135	
6	4.692756671	4.694107323	7.207593025	1.35E-03	
7	4.694107323	4.694091111	-0.625741879	-1.62116E-05	
8	4.694091111	4.694091133	-0.071490351	2.20227E-08	
9	4.694091133		0.000868508		

q2 root 3

iteration (n)	a_n	a_n+1	f(a)	a_n+1 - a_n
0	7	8	414.3774489	1
1	8	7.657489196	-215.8647684	-0.342510804
2	7.657489196	7.82540077	414.3774489	0.167911574
3	7.82540077	7.861542914	-215.8647684	0.036142144
4	7.861542914	7.854555381	207.5965224	-0.006987534
5	7.854555381	7.854756074	36.76964842	0.000200694
6	7.854756074	7.854757439	-8.812642506	1.36E-06
7	7.854757439		0.260598719	

3a)

$$x_0 = -1$$

$$\text{tol} = 10^{-6}$$

{Newton's Method}

3b)

$$x_0 = -1$$

$$\text{tol} = 10^{-6}$$

$n = 1$
while $\epsilon_n > \text{tol}$

$$x_{n+1} = x_n - \frac{f'(x_n)}{[f'(x_n)]^2 - f'(x_n)f''(x_n)}$$

$$n = n + 1$$

The method used in part B converges much faster than the method used in part A. Method B has a quadratic rate of convergence while method A has a linear rate of convergence.

q3 newton's method 1 of 2

iteration	x_n	x_n+1	x_n+1 - x_n
0	-1	-0.31304943300449195	0.686950566995508
1	-0.31304943300449195	-0.2636505666726228	0.04939886633186913
2	-0.2636505666726228	-0.23457786469372593	0.029072701978896887
3	-0.23457786469372593	-0.21656194195855072	0.018015922735175216
4	-0.21656194195855072	-0.2050820146358082	0.011479927322742528
5	-0.2050820146358082	-0.19764570909941012	0.007436305536398069
6	-0.19764570909941012	-0.19277960914511322	0.004866099954296904
7	-0.19277960914511322	-0.18957480323130374	0.0032048059138094775
8	-0.18957480323130374	-0.18745532553472577	0.0021194776965779705
9	-0.18745532553472577	-0.186049810478207	0.001405515056518758
10	-0.186049810478207	-0.18511608796794457	0.0009337225102624414
11	-0.18511608796794457	-0.18449505791118137	0.0006210300567631999
12	-0.18449505791118137	-0.18408168025822427	0.0004133776529570976
13	-0.18408168025822427	-0.18380637982069103	0.00027530043753323796
14	-0.18380637982069103	-0.18362297251725587	0.00018340730343516243
15	-0.18362297251725587	-0.18350075699513327	0.000122215522122604
16	-0.18350075699513327	-0.1834193048651846	8.145212994867257e-05
17	-0.1834193048651846	-0.1833650158769222	5.428898826240203e-05
18	-0.1833650158769222	-0.18332882638451586	3.618949240632996e-05
19	-0.18332882638451586	-0.1833047070220908	2.4119362425051305e-05
20	-0.1833047070220908	-0.18328861872901317	1.6088293077642923e-05
21	-0.18328861872901317	-0.18327787866022516	1.0740068788012147e-05
22	-0.18327787866022516	-0.1832707472090781	7.13145114705771e-06
23	-0.1832707472090781	-0.1832659492181092	4.797990968891108e-06
24	-0.1832659492181092	-0.18326263223416403	3.316983945178542e-06
25	-0.18326263223416403	-0.18326099126148293	1.6409726810995284e-06
26	-0.18326099126148293		

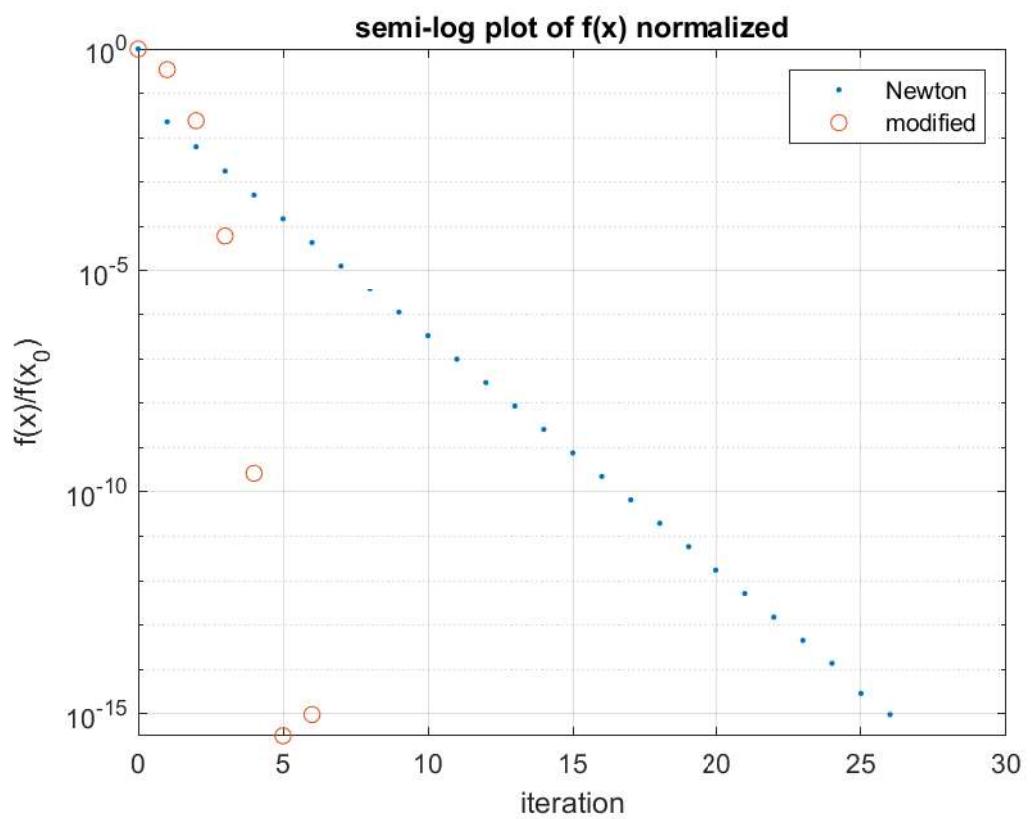
q3 newton's method 2 of 2

f(x)
-0.17356546601839162
-0.003979887996199083
-0.0010911840842249831
-0.00030914914499952095
-8.911713760723083e-05
-2.5949530432833878e-05
-7.602880819634894e-06
-2.236249355636044e-06
-6.594054887121281e-07
-1.947580318684139e-07
-5.758439464154108e-08
-1.7038142396952338e-08
-5.043635120660639e-09
-1.4934838366009728e-09
-4.423308941348125e-10
-1.310250241637334e-10
-3.881511778658364e-11
-1.1499079466403828e-11
-3.4071079291209116e-12
-1.0092482405354986e-12
-2.9926061628771095e-13
-8.876233081878127e-14
-2.6145752229922437e-14
-7.827072323607354e-15
-2.3869795029440866e-15
-4.996003610813204e-16
-1.6653345369377348e-16

q3 modified newton

Iteration	x_n	x_n+1	x_n+1 - x_n	f(x)
0	-1	-0.59762	0.402376229	-0.17357
1	-0.59762	-0.31592	0.281699298	-0.05956
2	-0.31592	-0.1994	0.116525903	-0.00422
3	-0.1994	-0.18351	0.015884323	-1.07E-05
4	-0.18351	-0.18326	0.000257719	-4.56E-11
5	-0.18326	-0.18326	-3.36E-08	-5.55E-17
6	-0.18326			-1.67E-16

q3



$$4) C_p = .99403 + 1.671E-4 T - 9.7215E-8 T^2 - 9.5838 \times 10^{-11} T^3 \\ + 1.952 \times 10^{-14} T^4$$

choose g such that $-1 < g(T_0) < 1$

$$C_p = 1.2$$

$$\Rightarrow g(T) = \frac{1.2 - 9.9403}{\begin{pmatrix} 1.671E-4 + 9.7215E-8 T - 9.5838 E^{-11} T^2 \\ + 1.952 E^{-14} T^3 \end{pmatrix}}$$

$$t_0 = 10^{-5}$$

$n=0$
while $\epsilon_n > 0$ and $n < 99$

$$\left| \begin{array}{l} T_n = g(T_n) \\ n = n+1 \end{array} \right.$$

q4 T_0 = 500

iteration	T_n	T_n+1	eps_n	T_n+1 - T_n
0	500	1060.673162	1.121346324	560.6731621
1	1060.673162	1109.238752	0.045787516	48.56558975
2	1109.238752	1121.499972	0.011053725	12.2612199
3	1121.499972	1124.783198	0.002927532	3.283226585
4	1124.783198	1125.675149	0.000792998	0.891951168
5	1125.675149	1125.918397	0.000216091	0.243247986
6	1125.918397	1125.984804	5.90E-05	0.066406365
7	1125.984804	1126.002938	1.61E-05	0.018133993
8	1126.002938	1126.00789	4.39816E-06	0.004952344
9	1126.00789			-1126.00789

q4 T_0 = 2000

iteration	T_n	T_n+1	eps_n	T_n+1 - T_n
0	2000	1533.222171	0.233388915	-466.7778291
1	1533.222171	1277.617812	0.166710581	-255.6043594
2	1277.617812	1173.118071	0.081792645	-104.4997403
3	1173.118071	1139.429205	0.02871737	-33.68886569
4	1139.429205	1129.719711	0.008521367	-9.709494318
5	1129.719711	1127.026405	0.002384048	-2.693306553
6	1127.026405	1126.287663	0.000655479	-0.73874162
7	1126.287663	1126.085669	0.000179345	-0.201993553
8	1126.085669	1126.030486	4.90E-05	-0.055183385
9	1126.030486	1126.015414	1.34E-05	-0.015072206
10	1126.015414	1126.011297	-3.65572E-06	-0.004116398
11	1126.011297			-1126.011297

```

# Matthew Pahayo
# 1/28/2021
# computational methods
# hw 1
# question 1
# newtons method
# q1_nm.py

# create variable
import sympy as sym
x = sym.Symbol('x')

# define function, initial guess, and tol
f = 2*sym.sin(x**2)-3*sym.sin(x**2)+x**2*sym.sin(x**2)
t_0 = 2.2
tol = 10**-8

# lambdify funtion and its derivative
fp = sym.diff(f)
f = sym.lambdify(x, f)
fp = sym.lambdify(x, fp)

# get next iteration for t and declare lists
t_1 = t_0 - f(t_0)/fp(t_0)
tl = [t_0, t_1]
fl = []
dtl = []

# newtons method
n = 0
while (abs(tl[n+1]-tl[n])/abs(tl[n])) > tol:
    t_np1 = tl[n+1] - f(tl[n+1])/fp(tl[n+1])
    tl.append(t_np1)
    n += 1

# define fl and dtl
for j in range(len(tl)):
    fl.append(f(tl[j]))
for k in range(len(tl)-1):
    dtl.append(tl[k+1]-tl[k])

data_fl = open("fl.txt", "a")
data_tl = open("tl.txt", "a")
for i in range(len(tl)):
    data_tl.write(str(tl[i]) + "\n")
    data_fl.write(str(fl[i]) + "\n")
data_tl.close()
data_fl.close()

i = 0

```

```
data_dtl = open("dtl.txt", "a")
for i in range(len(dtl)):
    data_dtl.write(str(dtl[i]) + "\n")
data_dtl.close()

print("t = " + str(t_np1))
print("total iterations = " + str(n))
print("final delta t = " + str(dtl[n-1]))

# keeps python console up; for non-IDE use
i = 1
while i == 1:
    i = input("Press enter to continue.\n")
```

```

# Matthew Pahayo
# 2/11/2021
# computational methods
# hw 1
# question 1
# false position
# q1_fp.py

import numpy as nu

def f(x):
    f = 2*nu.sin(x**2)-3*nu.sin(x**2)+x**2*nu.sin(x**2)
    return f

a = 3.2
b = 3.8
tol = .00000001
cl = [a, b]
fl = [f(a), f(b)]
eps = []

i = 0
while abs(cl[i+1] - cl[i])/abs(cl[i]) >= tol:
    c = b-f(b)*(b-a)/(f(b)-f(a))
    eps.append(abs(cl[i+1] - cl[i])/abs(cl[i]))
    if f(c)*f(b) > 0:
        b = c
    if f(c)*f(b) < 0:
        a = c
    cl.append(c)
    fl.append(f(c))
    i += 1

eps.append(abs(cl[i+1] - cl[i])/abs(cl[i]))

i=0
data_fl = open("fl.txt", "a")
data_cl = open("cl.txt", "a")
for i in range(len(cl)):
    data_cl.write(str(cl[i]) + "\n")
for g in range(len(fl)):
    data_fl.write(str(fl[g]) + "\n")
data_cl.close()
data_fl.close()

i = 0
data_eps = open("eps.txt", "a")
for i in range(len(eps)):
    data_eps.write(str(eps[i]) + "\n")
data_eps.close()

```

```
print(c)
n = 1
while n == 1:
    n = input("Press enter to continue.")
```

```

# Matthew Pahayo
# 2/11/2021
# computational methods
# hw 1
# question 2
# secant method
# q2.py

import numpy as np

def f(x):
    return np.cosh(x)*np.cos(x)+1

# define tol, guess a_0 and a_1
# a_0 != 0, because of stopping criteria
tol = 10**-6
a_0 = 7
a_1 = 8

# declare lists
al = [a_0, a_1]
fl = [f(a_0), f(a_1)]
dal = []

# secant method
# evaluates function at a_n
n = 0
while (abs(al[n+1]-al[n])/abs(al[n])) > tol:
    a_np1 = al[n+1] - f(al[n+1])/(f(al[n+1])-f(al[n]))*((al[n+1])-al[n])
    al.append(a_np1)
    fl.append(f(al[n]))
    n += 1

# defines dal list
for k in range(len(al)-1):
    dal.append(al[k+1]-al[k])

i=0
data_fl = open("fl.txt", "a")
data_al = open("al.txt", "a")
for i in range(len(al)):
    data_al.write(str(al[i]) + "\n")
    data_fl.write(str(fl[i]) + "\n")
data_al.close()
data_fl.close()

i = 0
data_dal = open("dal.txt", "a")
for i in range(len(dal)):
    data_dal.write(str(dal[i]) + "\n")

```

```
data_dal.close()

print("a = " + str(a_np1))
print("total iterations = " + str(n))
print("final delta a = " + str(dal[n-1]))
```

```

# Matthew Pahayo
# 1/28/2021
# computational methods
# hw 1
# question 3
# newtons method
# q3_nm

# create variable
import sympy as sym
x = sym.Symbol('x')

# define function, initial guess, and tol
f = sym.exp(6*x)+3*sym.ln(2)**2*sym.exp(2*x)-sym.exp(4*x)*sym.ln(8)-sym.ln(2)**3
t_0 = -1
tol = 10**-5

# lambdify funtion and its derivative
fp = sym.diff(f)
f = sym.lambdify(x, f)
fp = sym.lambdify(x, fp)

# get next iteration for t and declare lists
t_1 = t_0 - f(t_0)/fp(t_0)
tl = [t_0, t_1]
fl = []
dtl = []

# newtons method
n = 0
while (abs(tl[n+1]-tl[n])/abs(tl[n])) > tol:
    t_np1 = tl[n+1] - f(tl[n+1])/fp(tl[n+1])
    tl.append(t_np1)
    n += 1

# define fl and dtl
for j in range(len(tl)):
    fl.append(f(tl[j]))
for k in range(len(tl)-1):
    dtl.append(tl[k+1]-tl[k])

data_fl = open("fl.txt", "a")
data_tl = open("tl.txt", "a")
for i in range(len(tl)):
    data_tl.write(str(tl[i]) + "\n")
    data_fl.write(str(fl[i]) + "\n")
data_tl.close()
data_fl.close()

i = 0

```

```
data_dtl = open("dtl.txt", "a")
for i in range(len(dtl)):
    data_dtl.write(str(dtl[i]) + "\n")
data_dtl.close()

print("t = " + str(t_np1))
print("total iterations = " + str(n))
print("final delta t = " + str(dtl[n-1]))

# keeps python console up; for non-IDE use
i = 1
while i == 1:
    i = input("Press enter to continue.\n")
```

```

% 2/11/2020
% Matthew Pahayo
% hw 1
% % q3 plot
% file Name: plt.m

clc
clear all
close all

f_m = importdata("f1m.txt");
f = importdata("f1.txt");

g_m = abs(f_m/f_m(1));
g = abs(f/f(1));

a = 0:length(g)-1;
a_m = 0:length(g_m)-1;

semilogy(a,g,'.',a_m,g_m,'o')
title('semi-log plot of f(x) normalized')
xlabel('iteration')
ylabel('f(x)/f(x_0)')
grid on
legend('Newton', 'modified')

```

```

# Matthew Pahayo
# 2/11/2021
# computational methods
# hw 1
# question 4
# fixed point
# q4.py

def g(x):
    return
(1.2-.99403)/(1.671*10**-4+9.7215*10**-8*x-9.5838*10**-11*x**2+1.952*10**-14*x**3)

tol = 10**-5
T_0 = 500
T_1 = g(T_0)

Tl = [T_0,T_1]
fl = [g(T_0),g(T_1)]
eps = []

n = 0
while (abs(Tl[n+1]-Tl[n])/abs(Tl[n])) > tol and n<99:
    T_np1 = g(Tl[n+1])
    Tl.append(T_np1)
    fl.append(T_np1)
    eps.append((abs(Tl[n+1]-Tl[n])/abs(Tl[n])))
    n += 1

i=0
data_fl = open("fl.txt", "a")
data_Tl = open("cl.txt", "a")
for i in range(len(Tl)):
    data_Tl.write(str(Tl[i]) + "\n")
for g in range(len(fl)):
    data_fl.write(str(fl[g]) + "\n")
data_Tl.close()
data_fl.close()

i = 0
data_eps = open("eps.txt", "a")
for i in range(len(eps)):
    data_eps.write(str(eps[i]) + "\n")
data_eps.close()

# keeps python console up; for non-IDE use
i = 1
while i == 1:
    i = input("Press enter to continue.\n")

```