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```
clc;
clear all;
close all;
load vpdataOLS;
```

Finding the initial estimates A_{in} and B_{in} using linear regression

```
N = length(psat);
y = log(psat); % Divided by 100 as converting to bar
temp = temp + 273;
x = 1./(temp+273);

covxy = cov(x,y);
meanx = mean(x);
meany = mean(y);
B_in = covxy(1,2)/covxy(1,1); % This is initial guess of B
A_in = meany - B_in*meanx; % This is initial guess of A

x0(1) = A_in;
x0(2) = -B_in;
x0(3) = 273;

options = optimoptions(@lsqnonlin,'Algorithm','levenberg-marquardt','Display','iter');
x_1 = lsqnonlin(@(x)fun(x,psat,temp),x0,[],[],options); % This is the non linear optimization function fun

x_2 = fmincon(@(x)fun1(x,psat,temp),x0, [], []); % This is the function fmincon which optimizes scalar returned by fun1
```

Iteration	Func-count	Resnorm	First-order optimality	Lambda	Norm of step
0	4	418.03	1.92e+03	0.01	
1	8	357.996	1.41e+03	0.001	9.91426
2	12	349.821	3.39	0.0001	1.46049
3	16	349.779	1.57	1e-05	14.4949
4	20	349.459	159	1e-06	144.555
5	25	349.035	166	1e-05	146.366
6	29	348.601	173	1e-06	148.149
7	34	348.157	180	1e-05	149.988
8	38	347.703	188	1e-06	151.887
9	43	347.237	197	1e-05	153.85
10	47	346.76	206	1e-06	155.876
11	52	346.272	215	1e-05	157.973
12	56	345.771	226	1e-06	160.143
13	61	345.258	237	1e-05	162.389
14	65	344.731	249	1e-06	164.715
15	70	344.192	261	1e-05	167.13
16	74	343.639	275	1e-06	169.634
17	79	343.071	290	1e-05	172.232
18	83	342.49	307	1e-06	174.929
19	88	341.893	324	1e-05	177.736
20	92	341.282	343	1e-06	180.654
21	97	340.656	364	1e-05	183.698
22	101	340.015	387	1e-06	186.86
23	106	339.36	412	1e-05	190.157
24	110	338.691	440	1e-06	193.596

25	115	338.01	470	1e-05	197.183
26	119	337.318	503	1e-06	200.929
27	124	336.616	540	1e-05	204.842
28	128	335.91	581	1e-06	208.926
29	133	335.202	627	1e-05	213.196
30	137	334.499	678	1e-06	217.651
31	142	333.81	735	1e-05	222.308
32	146	333.145	799	1e-06	227.161
33	151	332.52	871	1e-05	232.219
34	155	331.955	953	1e-06	237.467
35	160	331.476	1.04e+03	1e-05	242.907
36	164	331.119	1.15e+03	1e-06	248.517
37	169	330.93	1.27e+03	1e-05	254.264
38	174	324.319	17.5	0.0001	26.7538
39	178	324.175	14.4	1e-05	26.6986
40	183	324.031	14.6	0.0001	26.7678
41	187	323.886	14.7	1e-05	26.8379
42	192	323.741	14.9	0.0001	26.9074
43	196	323.595	15.1	1e-05	26.977
44	201	323.448	15.2	0.0001	27.0474
45	205	323.3	15.4	1e-05	27.1174
46	210	323.152	15.6	0.0001	27.1878
47	214	323.002	15.8	1e-05	27.2581
48	219	322.852	15.9	0.0001	27.3284
49	223	322.701	16.1	1e-05	27.399
50	228	322.55	16.3	0.0001	27.47
51	232	322.397	16.5	1e-05	27.5409
52	237	322.244	16.7	0.0001	27.6119
53	241	322.09	16.9	1e-05	27.6821
54	246	321.935	17.1	0.0001	27.7532
55	250	321.78	17.3	1e-05	27.8238
56	255	321.623	17.5	0.0001	27.8946
57	259	321.466	17.7	1e-05	27.9656
58	264	321.308	17.9	0.0001	28.0362
59	268	321.149	18.1	1e-05	28.107
60	273	320.99	18.3	0.0001	28.1777
61	277	320.829	18.5	1e-05	28.2484
62	282	320.668	18.7	0.0001	28.3188
63	286	320.506	19	1e-05	28.3891
64	291	320.343	19.2	0.0001	28.4587
65	295	320.179	19.4	1e-05	28.5288
66	300	320.015	19.6	0.0001	28.5986
67	304	319.85	19.9	1e-05	28.6682
68	309	319.684	20.1	0.0001	28.7369
69	313	319.517	20.4	1e-05	28.8061
70	318	319.349	20.6	0.0001	28.8747
71	322	319.18	20.8	1e-05	28.9422
72	327	319.011	21.1	0.0001	29.0107
73	331	318.841	21.4	1e-05	29.0777
74	336	318.67	21.6	0.0001	29.1441
75	340	318.499	21.9	1e-05	29.2105
76	345	318.326	22.1	0.0001	29.2759
77	349	318.153	22.4	1e-05	29.3408
78	354	317.979	22.7	0.0001	29.4053
79	358	317.804	22.9	1e-05	29.47
80	363	317.629	23.2	0.0001	29.5323
81	367	317.452	23.5	1e-05	29.5946
82	372	317.275	23.8	0.0001	29.6561
83	376	317.097	24.1	1e-05	29.7165
84	381	316.919	24.4	0.0001	29.7761
85	385	316.74	24.6	1e-05	29.8342
86	390	316.56	24.9	0.0001	29.8919
87	394	316.379	25.2	1e-05	29.9485
88	399	316.198	25.5	0.0001	30.0029

89	403	316.016	25.8	1e-05	30.0572
90	408	315.834	26.1	0.0001	30.1096
91	412	315.65	26.5	1e-05	30.1606
92	417	315.466	26.8	0.0001	30.21
93	421	315.282	27.1	1e-05	30.2582
94	426	315.097	27.4	0.0001	30.305
95	430	314.911	27.7	1e-05	30.3487
96	435	314.725	28	0.0001	30.3923
97	439	314.539	28.4	1e-05	30.4323
98	444	314.352	28.7	0.0001	30.4711
99	448	314.164	29	1e-05	30.5076
100	453	313.976	29.3	0.0001	30.5424
101	457	313.787	29.7	1e-05	30.5738
102	462	313.599	30	0.0001	30.6041
103	466	313.409	30.3	1e-05	30.6307
104	471	313.22	30.6	0.0001	30.656
105	475	313.03	31	1e-05	30.6763
106	480	312.84	31.3	0.0001	30.6945
107	484	312.65	31.6	1e-05	30.7104
108	489	312.459	31.9	0.0001	30.7234
109	493	312.269	32.3	1e-05	30.7321
110	498	312.078	32.6	0.0001	30.7367
111	502	311.888	32.9	1e-05	30.7385
112	507	311.697	33.2	0.0001	30.7358
113	511	311.506	33.5	1e-05	30.7294
114	516	311.316	33.8	0.0001	30.7193
115	520	311.125	34.1	1e-05	30.7042
116	525	310.935	34.4	0.0001	30.686
117	529	310.745	34.7	1e-05	30.661
118	534	310.556	35	0.0001	30.6316
119	538	310.367	35.3	1e-05	30.5994
120	543	310.178	35.5	0.0001	30.5589
121	547	309.99	35.8	1e-05	30.5136
122	552	309.802	36	0.0001	30.4632
123	556	309.615	36.3	1e-05	30.4076
124	561	309.429	36.5	0.0001	30.3457
125	565	309.244	36.7	1e-05	30.2783
126	570	309.059	36.9	0.0001	30.2035
127	574	308.876	37.1	1e-05	30.1212
128	579	308.693	37.3	0.0001	30.0324
129	583	308.512	37.4	1e-05	29.9349
130	588	308.332	37.6	0.0001	29.8336
131	592	308.153	37.7	1e-05	29.722
132	597	307.976	37.8	0.0001	29.6037
133	601	307.8	37.9	1e-05	29.4773
134	606	307.625	37.9	0.0001	29.3447
135	610	307.452	38	1e-05	29.2013
136	615	307.281	38	0.0001	29.049
137	619	307.112	38	1e-05	28.8898
138	624	306.945	37.9	0.0001	28.7219
139	628	306.78	37.9	1e-05	28.5435
140	633	306.617	37.8	0.0001	28.356
141	637	306.456	37.7	1e-05	28.158
142	642	306.297	37.5	0.0001	27.9528
143	646	306.141	37.4	1e-05	27.7375
144	651	305.987	37.1	0.0001	27.5079
145	655	305.836	36.9	1e-05	27.2809
146	660	305.688	36.7	0.0001	27.0394
147	664	305.542	36.3	1e-05	26.7804
148	669	305.399	36	0.0001	26.5122
149	673	305.259	35.7	1e-05	26.2401
150	678	305.122	35.3	0.0001	25.9497
151	682	304.988	34.8	1e-05	25.6521
152	687	304.858	34.4	0.0001	25.3482

153	691	304.73	33.9	1e-05	25.0322
154	696	304.606	33.3	0.0001	24.7079
155	700	304.485	32.8	1e-05	24.3723
156	705	304.367	32.2	0.0001	24.0261
157	709	304.253	31.6	1e-05	23.6756
158	714	304.142	30.9	0.0001	23.3155
159	718	304.035	30.3	1e-05	22.9445
160	723	303.931	29.6	0.0001	22.5645
161	727	303.831	28.8	1e-05	22.1769
162	732	303.734	28.1	0.0001	21.7846
163	736	303.64	27.3	1e-05	21.3838
164	741	303.551	26.6	0.0001	20.9763
165	745	303.464	25.8	1e-05	20.564
166	750	303.381	25	0.0001	20.1443
167	754	303.302	24.1	1e-05	19.7195
168	759	303.226	23.3	0.0001	19.2908
169	763	303.153	22.5	1e-05	18.8578
170	768	303.084	21.6	0.0001	18.4206
171	772	303.017	20.8	1e-05	17.9834
172	777	302.955	19.9	0.0001	17.5409
173	781	302.895	19.1	1e-05	17.0997
174	786	302.838	18.3	0.0001	16.6574
175	790	302.784	17.5	1e-05	16.2136
176	795	302.733	16.6	0.0001	15.7713
177	799	302.685	15.8	1e-05	15.3291
178	804	302.64	15.1	0.0001	14.8892
179	808	302.597	14.3	1e-05	14.452
180	813	302.557	13.5	0.0001	14.0162
181	817	302.519	12.8	1e-05	13.5858
182	822	302.483	12.1	0.0001	13.1589
183	826	302.45	11.4	1e-05	12.7366
184	831	302.419	10.7	0.0001	12.3186
185	835	302.39	10.1	1e-05	11.9069
186	840	302.363	9.47	0.0001	11.5021
187	844	302.337	8.88	1e-05	11.1026
188	849	302.314	8.31	0.0001	10.7098
189	853	302.292	7.76	1e-05	10.3258
190	858	302.272	7.24	0.0001	9.94904
191	862	302.253	6.75	1e-05	9.57857
192	867	302.235	6.28	0.0001	9.21972
193	871	302.219	5.84	1e-05	8.8665
194	876	302.204	5.42	0.0001	8.52208
195	880	302.191	5.02	1e-05	8.18682
196	885	302.178	4.65	0.0001	7.86087
197	889	302.166	4.3	1e-05	7.54342
198	894	302.156	3.97	0.0001	7.23684
199	898	302.146	3.66	1e-05	6.93727
200	903	302.137	3.38	0.0001	6.64793
201	907	302.128	3.11	1e-05	6.36713
202	912	302.121	2.86	0.0001	6.09528
203	916	302.114	2.63	1e-05	5.83373
204	921	302.107	2.41	0.0001	5.57933
205	925	302.101	2.21	1e-05	5.33413
206	930	302.096	2.02	0.0001	5.09898
207	934	302.091	1.85	1e-05	4.87109
208	939	302.087	1.69	0.0001	4.6528
209	943	302.083	1.55	1e-05	4.44217
210	947	302.08	69.7	1e-06	29.6919
211	952	302.055	31.4	1e-05	19.7655
212	956	302.047	13.7	1e-06	13.0019
213	961	302.045	5.88	1e-05	8.49283
214	965	302.044	2.49	1e-06	5.51392
215	969	302.043	6	1e-07	8.5468
216	973	302.043	0.18	1e-08	1.47729

Local minimum possible.

lsqnonlin stopped because the final change in the sum of squares relative to its initial value is less than the value of the function tolerance.

Local minimum possible. Constraints satisfied.

fmincon stopped because the size of the current step is less than the value of the step size tolerance and constraints are satisfied to within the value of the constraint tolerance.

Printing and plotting

```
clc;

disp("The values obtained from fmincon are as follows: "); disp("");
fprintf("A: %0.4f\n", x_1(1));
fprintf("B: %0.4f\n", x_1(2));
fprintf("C: %0.4f\n", x_1(3));

disp("The values obtained from lsqnonlin are as follows: "); disp("");
fprintf("A: %0.4f\n", x_2(1));
fprintf("B: %0.4f\n", x_2(2));
fprintf("C: %0.4f\n", x_2(3));

scatter(temp, x_1(1) - x_1(2)./(temp + x_1(3)), "*", "red");
hold on;
scatter(temp, x_2(1) - x_2(2)./(temp + x_2(3)), "+", "blue");
legend("lsqnonlin", "fmincon");
xlabel("Temperature in Kelvin");
ylabel("ln(p^{sat}) in bar");
title("ln(p^{sat}) vs Temperature as per fmincon, lsqnonlin")
hold off;

function [res] = fun(x,y,T)
N = length(T);
res = zeros(N,1);
for i = 1:N
    res(i) = y(i) - exp(x(1) - x(2)/(T(i) + x(3)));
end
end

function res1 = fun1(x,y,T)
N = length(T);
res1 = 0;
for i = 1:N
    res1 = res1 + (y(i) - exp(x(1) - x(2)/(T(i) + x(3))))^2;
end
end
```

The values obtained from fmincon are as follows:

A: 13.7447
B: 2666.9261
C: -49.9435

The values obtained from lsqnonlin are as follows:

A: 13.7397
B: 2664.2370
C: -50.0789

