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Laboratorium #12. Teoria optymalizacji.

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```
% data for vehicle speed scheduling problem.
% contains quantities: n, a, b, c, d, smin, smax, tau_min, tau_max
n = 100;
a = 1;
b = 6;
c = 10;
d = [...
1.9501
1.2311
1.6068
1.4860
1.8913
1.7621
1.4565
1.0185
1.8214
1.4447
1.6154
1.7919
1.9218
1.7382
1.1763
1.4057
1.9355
1.9169
1.4103
1.8936
1.0579
1.3529
1.8132
1.0099
1.1389
1.2028
1.1987
1.6038
1.2722
1.1988
1.0153
1.7468
1.4451
1.9318
1.4660
1.4186
1.8462
1.5252
1.2026
1.6721
1.8381
1.0196
1.6813
```

```
1.3795
1.8318
1.5028
1.7095
1.4289
1.3046
1.1897
1.1934
1.6822
1.3028
1.5417
1.1509
1.6979
1.3784
1.8600
1.8537
1.5936
1.4966
1.8998
1.8216
1.6449
1.8180
1.6602
1.3420
1.2897
1.3412
1.5341
1.7271
1.3093
1.8385
1.5681
1.3704
1.7027
1.5466
1.4449
1.6946
1.6213
1.7948
1.9568
1.5226
1.8801
1.1730
1.9797
1.2714
1.2523
1.8757
1.7373
1.1365
1.0118
1.8939
1.1991
1.2987
1.6614
1.2844
1.4692
1.0648
1.9883
];
smin = [...
0.7828
0.6235
0.7155
0.5340
0.6329
```

0.4259
0.7798
0.9604
0.7298
0.8405
0.4091
0.5798
0.9833
0.8808
0.6611
0.7678
0.9942
0.2592
0.8029
0.2503
0.6154
0.5050
1.0744
0.2150
0.9680
1.1708
1.1901
0.9889
0.6387
0.6983
0.4140
0.8435
0.5200
1.1601
0.9266
0.6120
0.9446
0.4679
0.6399
1.1334
0.8833
0.4126
1.0392
0.8288
0.3338
0.4071
0.8072
0.8299
0.5705
0.7751
0.6514
0.2439
0.2272
0.5127
0.2129
0.5840
0.8831
0.2928
0.2353
0.8124
0.8085
0.2158
0.2164
0.3901
0.7869
0.2576
0.5676
0.8315

```
0.9176
0.8927
0.2841
0.6544
0.6418
0.5533
0.3536
0.8756
0.8992
0.9275
0.6784
0.7548
0.3210
0.6508
0.9159
1.0928
0.4731
0.4548
1.0656
0.4324
1.0049
1.1084
0.4319
0.4393
0.2498
0.2784
0.8408
0.3909
1.0439
0.3739
0.3708
1.1943
];
smax = [...
1.9624
1.6036
1.6439
1.5641
1.7194
1.9090
1.3193
1.3366
1.9470
2.8803
2.5775
1.4087
1.6039
2.9266
1.4369
2.3595
3.2280
1.8890
2.8436
0.5701
1.1894
2.4425
2.2347
2.2957
2.7378
2.8455
2.1823
1.6209
1.2499
1.3805
```

1.5589
2.8554
1.8005
3.0920
2.1482
1.8267
2.1459
1.5924
2.7431
1.4445
1.7781
0.8109
2.7256
2.4290
2.5997
1.8125
1.9073
1.5275
2.1209
2.5419
1.7032
0.5636
1.3669
2.3200
2.1006
2.7239
2.8726
1.3283
1.7769
2.5750
1.4963
2.3254
1.6548
1.9537
1.5557
1.6551
2.7307
1.8018
2.5287
1.9765
1.8387
2.3525
1.7362
1.6805
1.9640
2.8508
1.9424
2.0780
2.1677
2.1863
2.0541
1.9734
2.7687
2.3715
1.1449
2.1560
3.3310
2.3456
2.7120
2.3783
0.9611
2.0690
1.2805

```
0.8585
2.2744
2.3369
2.6918
2.6728
2.5941
1.6120
];
tau_min = [...
1.0809
2.7265
3.5118
5.3038
5.4516
7.1648
9.2674
12.1543
14.4058
16.6258
17.9214
19.8242
22.2333
22.4849
25.3213
28.0691
29.8751
30.6358
33.2561
34.7963
36.9943
38.2610
41.1451
41.3613
43.0215
43.8974
46.4713
47.4786
49.5192
49.6795
50.7495
52.2444
53.5477
55.2351
57.0850
57.4250
60.1198
62.3834
64.7568
67.2016
69.2116
69.8143
70.6335
72.5122
74.1228
74.3013
74.5682
75.3821
76.6093
78.0315
80.7584
82.5472
83.5340
84.9686
86.7601
```

```
87.2445
89.7329
92.6013
94.3879
94.4742
96.9105
98.7409
100.8453
101.1219
102.3966
103.5233
104.0218
106.5212
109.0372
110.3920
113.2618
113.7033
116.3131
118.6214
119.9539
121.8157
124.6708
126.5908
127.3328
128.3909
128.9545
130.4264
131.6542
133.0448
134.8776
135.0912
136.0340
137.8591
138.3842
140.2473
140.9852
142.7472
144.2654
145.6597
147.2840
150.1110
151.1363
152.3417
153.2647
154.4994
];
tau_max = [...
4.6528
6.5147
7.5178
9.7478
9.0641
10.3891
13.1540
16.0878
17.4352
20.9539
22.3695
23.3875
25.7569
26.9019
29.8890
33.0415
```

33.8218
35.4414
37.1583
39.4054
41.6520
41.5935
44.9329
45.4028
47.4577
48.0358
50.3929
51.3692
52.6947
53.5665
54.4821
55.8495
58.2514
59.7541
61.9845
61.5409
63.1482
66.5758
69.3892
72.1558
72.6555
74.2216
74.6777
77.3780
78.5495
77.7574
78.4675
78.7265
81.5470
81.7429
83.8565
87.0579
88.3237
88.5409
90.2625
92.1100
92.9949
97.4829
98.7916
99.1695
100.3291
102.6510
104.0075
105.8242
106.5207
107.1619
107.7716
111.2568
112.7815
113.5394
116.6615
116.8022
120.4465
121.8652
123.9981
125.0498
129.2106
130.3409
131.9796
131.4842


```

133.1503
135.3247
135.2318
137.8225
138.0808
138.2218
139.5026
142.7253
141.5105
143.7757
145.9842
146.1712
148.2622
149.2407
151.6295
155.0270
155.6694
156.6739
156.5266
157.6903
];
d1 = d;

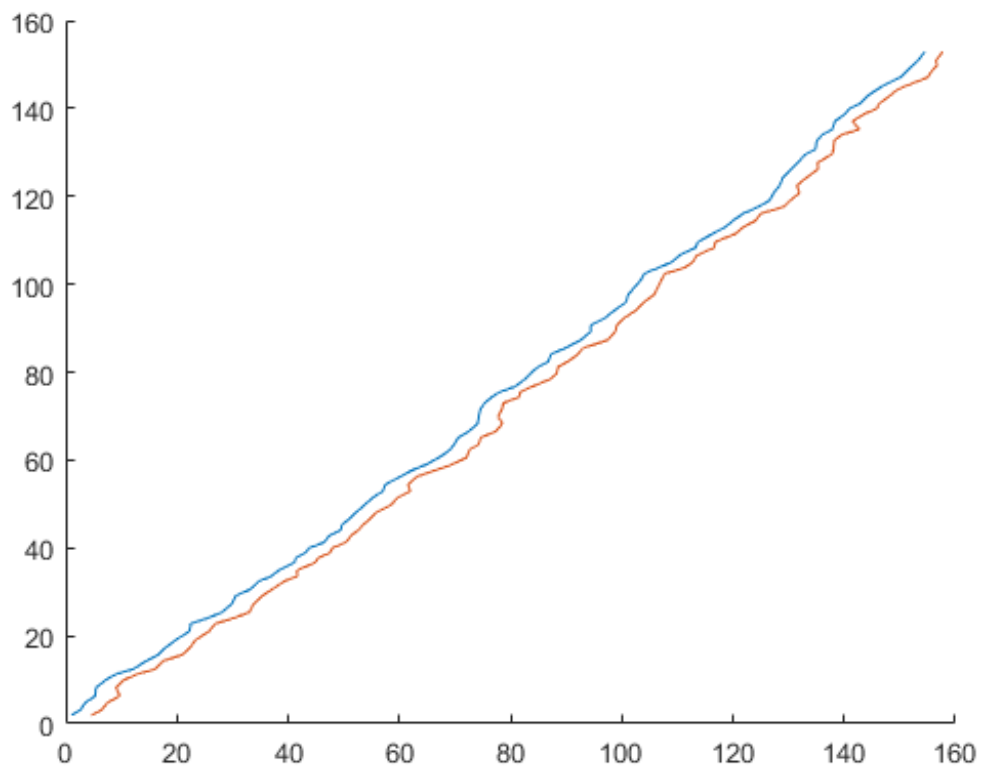
for i = 2:100
    d1(i) = d1(i-1) + d(i);
end

```

```

figure(1)
hold on
plot(tau_min, d1)
plot(tau_max, d1)
hold off

```



```

figure(2)
hold on
plot(d1, smin)
plot(d1, smax)
hold off

cvx_clear;

cvx_begin quiet
    variable tau(n)
    minimize sum(a*d.^2.*inv_pos(tau) + b*d + c*tau)
        % Ograniczenia wynikające z przedziału prędkości
        tau <= d./smin
        tau >= d./smax

        % Oraz czasu
        tau_min <= cumsum(tau)
        tau_max >= cumsum(tau)
cvx_end

s=d./tau % prędkość to droga przez czas

```

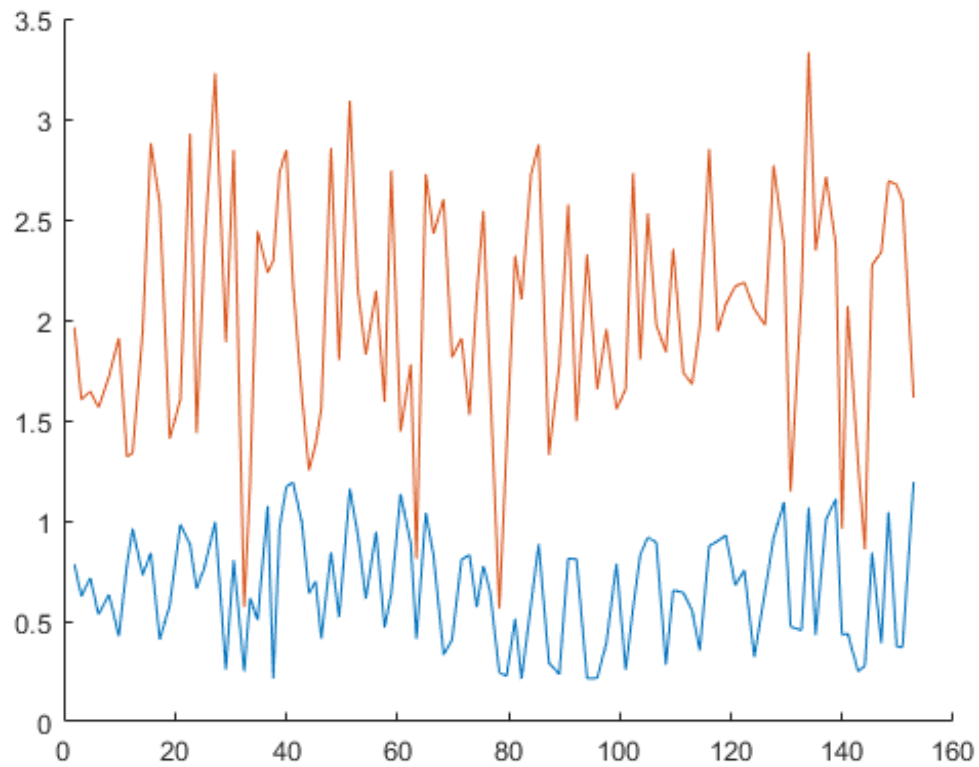
s =

```

0.9556
0.9556
0.9556
0.9556
0.9556
0.8338
0.9604
0.8338
0.8405
0.8338
0.8338
0.9833
0.8808
0.8338
0.8338
0.9942
0.8338
0.8338
0.5701
0.8338
0.8338
1.0744
0.8338
0.9680
1.1708
1.1901
0.9889
0.8707
0.8707
0.8707
0.8707
0.8707
1.1601
0.9266
0.8707
0.9446
0.8707

```

0.8707
1.1334
0.9145
0.8109
1.1546
1.1546
1.1546
1.1546
1.1546
1.1546
1.0648
1.0648
1.0648
0.5636
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
1.0648
0.8739
0.9176
0.8927
0.8739
0.8739
0.8739
0.8739
0.8739
0.8739
0.8756
0.8992
0.9275
1.2254
1.2254
1.2254
1.2254
1.2254
1.2254
1.1449
1.2254
1.2254
1.2254
1.2254
1.2254
0.9611
1.2254
1.2254
0.8585
1.2254
1.2254
1.2254
1.2254
1.2254
1.2254
1.6104



```
figure(3);  
  
stairs(s), grid on;  
  
hold on;  
stairs(smin);  
  
stairs(smax);  
  
tau_min  
tau_max
```

```
tau_min =  
  
1.0809  
2.7265  
3.5118  
5.3038  
5.4516  
7.1648  
9.2674  
12.1543  
14.4058  
16.6258  
17.9214  
19.8242  
22.2333  
22.4849  
25.3213  
28.0691  
29.8751  
30.6358  
33.2561  
34.7963
```

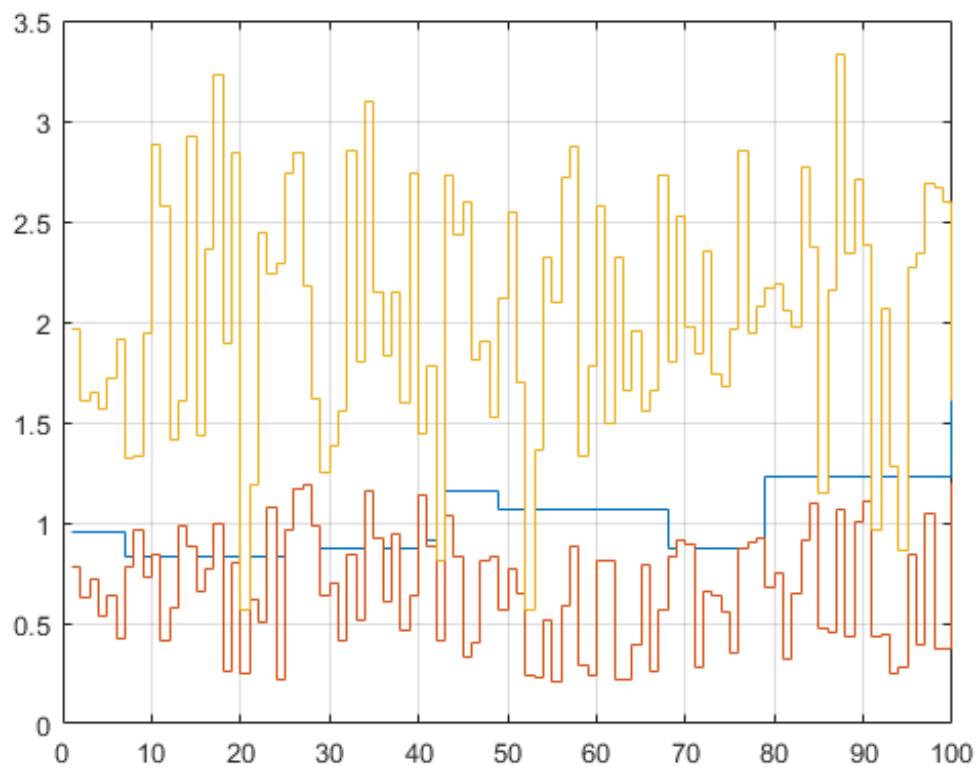
36.9943
38.2610
41.1451
41.3613
43.0215
43.8974
46.4713
47.4786
49.5192
49.6795
50.7495
52.2444
53.5477
55.2351
57.0850
57.4250
60.1198
62.3834
64.7568
67.2016
69.2116
69.8143
70.6335
72.5122
74.1228
74.3013
74.5682
75.3821
76.6093
78.0315
80.7584
82.5472
83.5340
84.9686
86.7601
87.2445
89.7329
92.6013
94.3879
94.4742
96.9105
98.7409
100.8453
101.1219
102.3966
103.5233
104.0218
106.5212
109.0372
110.3920
113.2618
113.7033
116.3131
118.6214
119.9539
121.8157
124.6708
126.5908
127.3328
128.3909
128.9545
130.4264
131.6542
133.0448

134.8776
135.0912
136.0340
137.8591
138.3842
140.2473
140.9852
142.7472
144.2654
145.6597
147.2840
150.1110
151.1363
152.3417
153.2647
154.4994

tau_max =

4.6528
6.5147
7.5178
9.7478
9.0641
10.3891
13.1540
16.0878
17.4352
20.9539
22.3695
23.3875
25.7569
26.9019
29.8890
33.0415
33.8218
35.4414
37.1583
39.4054
41.6520
41.5935
44.9329
45.4028
47.4577
48.0358
50.3929
51.3692
52.6947
53.5665
54.4821
55.8495
58.2514
59.7541
61.9845
61.5409
63.1482
66.5758
69.3892
72.1558
72.6555
74.2216
74.6777

77.3780
78.5495
77.7574
78.4675
78.7265
81.5470
81.7429
83.8565
87.0579
88.3237
88.5409
90.2625
92.1100
92.9949
97.4829
98.7916
99.1695
100.3291
102.6510
104.0075
105.8242
106.5207
107.1619
107.7716
111.2568
112.7815
113.5394
116.6615
116.8022
120.4465
121.8652
123.9981
125.0498
129.2106
130.3409
131.9796
131.4842
133.1503
135.3247
135.2318
137.8225
138.0808
138.2218
139.5026
142.7253
141.5105
143.7757
145.9842
146.1712
148.2622
149.2407
151.6295
155.0270
155.6694
156.6739
156.5266
157.6903



Wnioski

Funkcja celu jest to funkcja dwóch zmiennych i nie jest wypukła. Wynika to z faktu, iż funkcja $(a \cdot d.^2 \cdot \tau) + b \cdot d + c \cdot \tau$ posiada drugą pochodną cząstkową równą zero, co prowadzi do wniosku, iż funkcja ta nie posiada punktów przegięcia i tym samym nie jest wypukła (podobnie, jak w przypadku zwykłej funkcji liniowej).