Convex Optimization

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```
% Hw8-Q1:
clear;
clc;
close all;
% Load Data:
run('spacecraft_landing_data.m');
```

Optimize using CVX_MATLAB:

```
%%% Part (a):
cvx_begin
        variables p(3,K+1) v(3,K+1) f(3,K)

        v(:,2:K+1) == v(:,1:K) + 1/m*h*f - h * g * repmat([0;0;1],1,K);

        p(:,2:K+1) == p(:,1:K)+(h/2)*(v(:,1:K)+v(:,2:K+1));
        p(:,1) == p0;
        p(:,K+1) == 0;
        v(:,K+1) == 0;
        v(:,1) == v0;
        p(3,:)   >= alpha*norms(p(1:2,:));
        norms(f) <= Fmax;

        minimize(sum(norms(f)))

cvx_end
```

```
Calling SDPT3 4.0: 507 variables, 302 equality constraints
------------------------------------------------------------

 num. of constraints = 302
 dim. of socp   var  = 388,   num. of socp blk  = 106
 dim. of linear var  = 71
 dim. of free   var  = 48 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-------------------------------------------------------------------
 0|0.000|0.000|1.8e+01|1.4e+02|9.0e+07| 4.713333e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.059|0.020|1.7e+01|1.3e+02|1.9e+07| 3.170669e+04 -5.811568e+03| 0:0:00| chol  1  1
 2|0.284|0.807|1.2e+01|2.6e+01|1.5e+06| 3.654045e+04 -2.540090e+04| 0:0:00| chol  1  1
 3|0.907|0.940|1.1e+00|1.7e+00|1.2e+05| 1.645730e+04 -2.370420e+04| 0:0:01| chol  1  1
 4|0.801|0.894|2.2e-01|2.0e-01|2.5e+04| 4.267603e+03 -1.031453e+04| 0:0:01| chol  1  1
```

```
 5|0.771|0.376|5.0e-02|1.3e-01|1.1e+04| 1.374925e+03 -7.145819e+03| 0:0:01| chol  1  1
 6|0.848|0.550|7.6e-03|6.0e-02|4.2e+03| 3.945439e+02 -3.487871e+03| 0:0:01| chol  1  1
 7|0.936|0.403|4.9e-04|3.7e-02|2.4e+03| 2.838562e+02 -2.058125e+03| 0:0:01| chol  1  1
 8|0.878|0.515|5.9e-05|1.8e-02|1.2e+03| 2.521076e+02 -9.089016e+02| 0:0:01| chol  1  1
 9|0.484|0.405|3.1e-05|1.1e-02|7.1e+02| 2.375506e+02 -4.630743e+02| 0:0:01| chol  1  1
10|0.436|0.161|1.7e-05|1.2e-02|5.9e+02| 2.260514e+02 -3.596379e+02| 0:0:01| chol  1  1
11|0.394|0.324|1.0e-05|7.9e-03|4.1e+02| 2.184868e+02 -1.865666e+02| 0:0:01| chol  1  1
12|0.502|0.159|5.2e-06|8.7e-03|3.4e+02| 2.103193e+02 -1.285027e+02| 0:0:01| chol  1  1
13|0.353|0.298|3.4e-06|6.1e-03|2.5e+02| 2.075513e+02 -3.862882e+01| 0:0:01| chol  1  1
14|0.550|0.186|1.5e-06|6.6e-03|2.0e+02| 2.028502e+02  2.396573e+00| 0:0:01| chol  1  1
15|0.431|0.362|8.7e-07|4.2e-03|1.4e+02| 2.010144e+02  6.711954e+01| 0:0:01| chol  1  1
16|0.650|0.266|3.0e-07|3.1e-03|1.0e+02| 1.976417e+02  9.934713e+01| 0:0:01| chol  1  1
17|0.498|0.267|1.5e-07|2.3e-03|7.4e+01| 1.964812e+02  1.231341e+02| 0:0:01| chol  1  1
18|0.577|0.266|6.4e-08|1.7e-03|5.5e+01| 1.952825e+02  1.411289e+02| 0:0:01| chol  1  1
19|0.484|0.226|3.3e-08|1.3e-03|4.3e+01| 1.947290e+02  1.523620e+02| 0:0:01| chol  1  1
20|0.575|0.306|1.4e-08|9.0e-04|3.0e+01| 1.941225e+02  1.644788e+02| 0:0:01| chol  1  1
21|0.667|0.319|4.7e-09|6.1e-04|2.0e+01| 1.935965e+02  1.734350e+02| 0:0:01| chol  1  1
22|0.692|0.391|1.5e-09|3.7e-04|1.2e+01| 1.932916e+02  1.810064e+02| 0:0:01| chol  1  1
23|0.843|0.321|2.6e-10|2.5e-04|8.4e+00| 1.930897e+02  1.848119e+02| 0:0:01| chol  1  1
24|1.000|0.185|2.9e-10|2.7e-04|6.9e+00| 1.930929e+02  1.862843e+02| 0:0:01| chol  1  1
25|0.874|0.500|1.7e-10|1.3e-04|3.5e+00| 1.930584e+02  1.895604e+02| 0:0:01| chol  1  1
26|1.000|0.640|3.3e-11|4.8e-05|1.3e+00| 1.930029e+02  1.917388e+02| 0:0:01| chol  1  1
27|1.000|0.271|2.4e-11|3.5e-05|9.4e-01| 1.929992e+02  1.920736e+02| 0:0:01| chol  1  1
28|1.000|0.326|2.5e-11|2.4e-05|6.4e-01| 1.929995e+02  1.923667e+02| 0:0:01| chol  1  1
29|1.000|0.316|1.7e-11|1.6e-05|4.4e-01| 1.929966e+02  1.925600e+02| 0:0:01| chol  1  1
30|1.000|0.394|1.8e-11|9.9e-06|2.7e-01| 1.929948e+02  1.927268e+02| 0:0:01| chol  1  1
31|1.000|0.348|2.1e-11|6.4e-06|1.8e-01| 1.929932e+02  1.928173e+02| 0:0:01| chol  1  1
32|1.000|0.393|1.2e-11|3.9e-06|1.1e-01| 1.929926e+02  1.928844e+02| 0:0:01| chol  1  1
33|1.000|0.338|1.1e-11|2.6e-06|7.3e-02| 1.929920e+02  1.929199e+02| 0:0:01| chol  1  1
34|1.000|0.387|7.8e-12|1.6e-06|4.5e-02| 1.929918e+02  1.929470e+02| 0:0:01| chol  1  1
35|1.000|0.335|4.3e-11|3.3e-05|3.4e-02| 1.929915e+02  1.929616e+02| 0:0:01| chol  1  1
36|1.000|0.920|3.6e-12|3.6e-05|5.1e-03| 1.929915e+02  1.929883e+02| 0:0:01| chol  1  1
37|0.526|0.941|2.0e-12|5.6e-06|5.9e-04| 1.929914e+02  1.929910e+02| 0:0:01| chol  1  1
38|0.514|0.932|8.8e-13|6.6e-07|1.4e-04| 1.929913e+02  1.929912e+02| 0:0:01| chol  1  1
39|0.523|0.738|1.8e-11|1.6e-07|6.6e-05| 1.929913e+02  1.929912e+02| 0:0:01| chol  1  1
40|0.518|0.705|1.3e-11|8.1e-08|3.5e-05| 1.929912e+02  1.929912e+02| 0:0:01| chol  2  1
41|0.518|0.706|2.5e-11|4.3e-08|1.9e-05| 1.929912e+02  1.929912e+02| 0:0:01| chol  2  1
42|0.519|0.708|9.0e-12|2.3e-08|9.9e-06| 1.929912e+02  1.929912e+02| 0:0:01| chol  2  1
43|0.519|0.707|1.4e-11|1.2e-08|5.3e-06| 1.929912e+02  1.929912e+02| 0:0:01|
  stop: max(relative gap, infeasibilities) < 1.49e-08
------------------------------------------------------------------------
 number of iterations   = 43
 primal objective value =  1.92991228e+02
 dual   objective value =  1.92991223e+02
 gap := trace(XZ)       = 5.27e-06
 relative gap           = 1.36e-08
 actual relative gap    = 1.28e-08
 rel. primal infeas (scaled problem)   = 1.38e-11
 rel. dual     "        "       "      = 1.22e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.9e+02, 6.2e+04, 7.0e+04
 norm(A), norm(b), norm(C) = 3.3e+01, 2.0e+02, 6.9e+00
 Total CPU time (secs)  = 1.01
 CPU time per iteration = 0.02
 termination code       =  0
 DIMACS: 2.7e-11  0.0e+00  4.2e-08  0.0e+00  1.3e-08  1.4e-08
------------------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +192.991
```

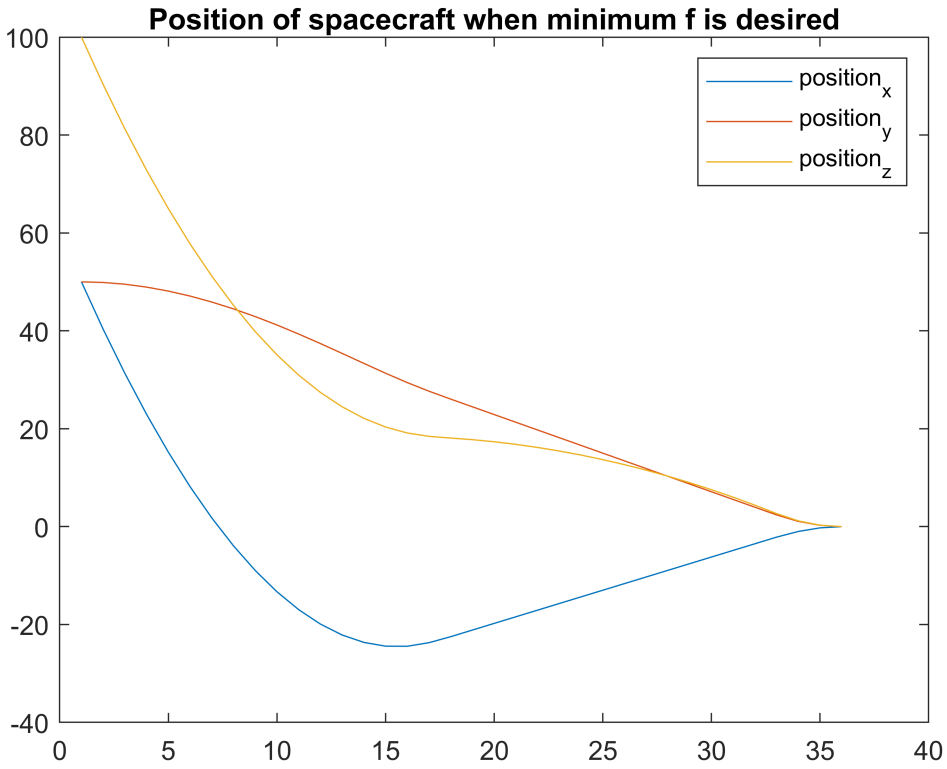
```
thrust_force  = cvx_optval;
min_fuel = thrust_force *gamma*h;

p_minf = p; v_minf = v; f_minf = f;
```

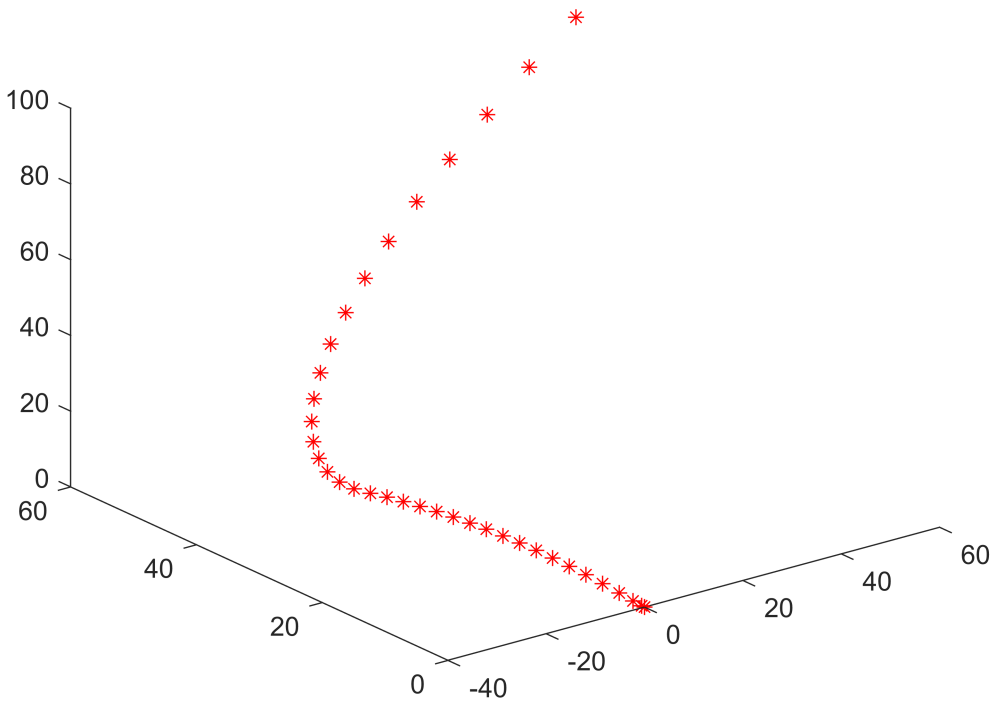
```
% Display Answers:
sprintf("minimum fuel value : %.2f",min_fuel)
```

```
ans =
"minimum fuel value : 192.99"
```

```
figure()
plot(1:length(p(1,:)),p);
title('Position of spacecraft when minimum f is desired')
legend('position_x','position_y','position_z')
```




```
% Trajectory:
Fig1=figure();
for i=1:length(p(1,:))
  plot3(p(1,i),p(2,i),p(3,i),'*r');
  hold on;
  pause(0.1);
end
```



Part (b)

```
% Find Min K
Ki = K;

while(1)
    cvx_begin
            variables p(3,Ki+1) v(3,Ki+1) f(3,Ki)
            % Constraints:
            v(:,2:Ki+1) == v(:,1:Ki)+(h/m)*f-h*g*repmat([0;0;1],1,Ki)
            p(:,2:Ki+1) == p(:,1:Ki)+(h/2)*(v(:,1:Ki)+v(:,2:Ki+1));
            p(:,1) == p0; v(:,1) == v0;
            p(:,Ki+1) == 0; v(:,Ki+1) == 0;
            p(3,:) >= alpha*norms(p(1:2,:));
            norms(f) <= Fmax;

    minimize(sum(norms(f))) % The Objective

    cvx_end
    if(strcmp(cvx_status,'Infeasible') == 1)
        Kmin = Ki+1; % we find out this K is not feasible and previous K was the minimum!
        break;
    end
    Ki = Ki-1; % Reduce K until it is not feasible!
    p_mink = p; v_mink = v; f_mink = f;
```

```
end
```

```
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------------------------------------------------------------

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 dim. of linear var  = 71
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17|0.498|0.267|1.5e-07|2.3e-03|7.4e+01| 1.964812e+02  1.231341e+02| 0:0:00| chol  1  1
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23|0.843|0.321|2.6e-10|2.5e-04|8.4e+00| 1.930897e+02  1.848119e+02| 0:0:00| chol  1  1
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26|1.000|0.640|3.3e-11|4.8e-05|1.3e+00| 1.930029e+02  1.917388e+02| 0:0:00| chol  1  1
27|1.000|0.271|2.4e-11|3.5e-05|9.4e-01| 1.929992e+02  1.920736e+02| 0:0:00| chol  1  1
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30|1.000|0.394|1.8e-11|9.9e-06|2.7e-01| 1.929948e+02  1.927268e+02| 0:0:00| chol  1  1
31|1.000|0.348|2.1e-11|6.4e-06|1.8e-01| 1.929932e+02  1.928173e+02| 0:0:00| chol  1  1
32|1.000|0.393|1.2e-11|3.9e-06|1.1e-01| 1.929926e+02  1.928844e+02| 0:0:00| chol  1  1
33|1.000|0.338|1.1e-11|2.6e-06|7.3e-02| 1.929920e+02  1.929199e+02| 0:0:00| chol  1  1
34|1.000|0.387|7.8e-12|1.6e-06|4.5e-02| 1.929918e+02  1.929470e+02| 0:0:00| chol  1  1
35|1.000|0.335|4.3e-11|3.3e-05|3.4e-02| 1.929915e+02  1.929616e+02| 0:0:00| chol  1  1
36|1.000|0.920|3.6e-12|3.6e-05|5.1e-03| 1.929915e+02  1.929883e+02| 0:0:00| chol  1  1
37|0.526|0.941|2.0e-12|5.6e-06|5.9e-04| 1.929914e+02  1.929910e+02| 0:0:01| chol  1  1
38|0.514|0.932|8.8e-13|6.6e-07|1.4e-04| 1.929913e+02  1.929912e+02| 0:0:01| chol  1  1
39|0.523|0.738|1.8e-11|1.6e-07|6.6e-05| 1.929913e+02  1.929912e+02| 0:0:01| chol  1  1
40|0.518|0.705|1.3e-11|8.1e-08|3.5e-05| 1.929912e+02  1.929912e+02| 0:0:01| chol  2  1
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42|0.519|0.708|9.0e-12|2.3e-08|9.9e-06| 1.929912e+02  1.929912e+02| 0:0:01| chol  2  1
43|0.519|0.707|1.4e-11|1.2e-08|5.3e-06| 1.929912e+02  1.929912e+02| 0:0:01|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-------------------------------------------------------------------
 number of iterations   = 43
```

```
 primal objective value =  1.92991228e+02
 dual   objective value =  1.92991223e+02
 gap := trace(XZ)       = 5.27e-06
 relative gap           = 1.36e-08
 actual relative gap    = 1.28e-08
 rel. primal infeas (scaled problem)   = 1.38e-11
 rel. dual     "        "       "      = 1.22e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.9e+02, 6.2e+04, 7.0e+04
 norm(A), norm(b), norm(C) = 3.3e+01, 2.0e+02, 6.9e+00
 Total CPU time (secs)  = 0.55
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 2.7e-11  0.0e+00  4.2e-08  0.0e+00  1.3e-08  1.4e-08
-----------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +192.991


Calling SDPT3 4.0: 491 variables, 292 equality constraints
------------------------------------------------------------

 num. of constraints = 292
 dim. of socp   var  = 377,   num. of socp blk  = 103
 dim. of linear var  = 69
 dim. of free   var  = 45 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-----------------------------------------------------------------
 0|0.000|0.000|1.7e+01|1.3e+02|7.4e+07| 4.578667e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.067|0.023|1.6e+01|1.2e+02|1.5e+07| 3.043640e+04 -5.708477e+03| 0:0:00| chol  1  1
 2|0.297|0.831|1.1e+01|2.1e+01|1.2e+06| 3.441421e+04 -2.419154e+04| 0:0:00| chol  1  1
 3|0.915|0.945|9.7e-01|1.2e+00|9.6e+04| 1.346896e+04 -2.188273e+04| 0:0:00| chol  1  1
 4|0.787|0.871|2.1e-01|1.9e-01|2.2e+04| 3.766795e+03 -9.324499e+03| 0:0:00| chol  1  1
 5|0.760|0.351|4.9e-02|1.2e-01|1.0e+04| 1.274992e+03 -6.627110e+03| 0:0:00| chol  1  1
 6|0.850|0.540|7.4e-03|5.8e-02|3.9e+03| 3.811206e+02 -3.287015e+03| 0:0:00| chol  1  1
 7|0.935|0.406|4.8e-04|3.6e-02|2.3e+03| 2.817367e+02 -1.926266e+03| 0:0:00| chol  1  1
 8|0.871|0.519|6.2e-05|1.7e-02|1.1e+03| 2.504667e+02 -8.385130e+02| 0:0:00| chol  1  1
 9|0.486|0.412|3.2e-05|1.0e-02|6.6e+02| 2.363865e+02 -4.146583e+02| 0:0:00| chol  1  1
10|0.427|0.147|1.8e-05|1.1e-02|5.6e+02| 2.257736e+02 -3.273197e+02| 0:0:00| chol  1  1
11|0.406|0.346|1.1e-05|7.4e-03|3.8e+02| 2.182030e+02 -1.526808e+02| 0:0:00| chol  1  1
12|0.531|0.172|5.1e-06|8.0e-03|3.1e+02| 2.096820e+02 -9.511957e+01| 0:0:00| chol  1  1
13|0.351|0.295|3.3e-06|5.7e-03|2.3e+02| 2.071974e+02 -1.561519e+01| 0:0:00| chol  1  1
14|0.546|0.186|1.5e-06|6.1e-03|1.8e+02| 2.029178e+02  2.130997e+01| 0:0:00| chol  1  1
15|0.429|0.368|8.6e-07|3.9e-03|1.2e+02| 2.012064e+02  8.071778e+01| 0:0:00| chol  1  1
16|0.663|0.274|2.9e-07|2.8e-03|8.9e+01| 1.979167e+02  1.105459e+02| 0:0:00| chol  1  1
17|0.491|0.282|1.5e-07|2.0e-03|6.5e+01| 1.969123e+02  1.328249e+02| 0:0:00| chol  1  1
18|0.601|0.258|5.9e-08|1.5e-03|4.8e+01| 1.957301e+02  1.480365e+02| 0:0:00| chol  1  1
19|0.484|0.290|3.0e-08|1.1e-03|3.5e+01| 1.952393e+02  1.607586e+02| 0:0:00| chol  1  1
20|0.645|0.286|1.1e-08|7.6e-04|2.5e+01| 1.945777e+02  1.699776e+02| 0:0:00| chol  1  1
21|0.663|0.464|3.6e-09|4.1e-04|1.3e+01| 1.941666e+02  1.808523e+02| 0:0:00| chol  1  1
22|0.835|0.396|6.1e-10|2.5e-04|8.0e+00| 1.938423e+02  1.859023e+02| 0:0:00| chol  1  1
23|1.000|0.693|5.0e-11|7.5e-05|2.5e+00| 1.937119e+02  1.912834e+02| 0:0:00| chol  1  1
24|0.971|0.132|8.8e-11|6.5e-05|2.1e+00| 1.937094e+02  1.915961e+02| 0:0:00| chol  1  1
25|1.000|0.385|1.1e-10|4.0e-05|1.4e+00| 1.937140e+02  1.923810e+02| 0:0:00| chol  1  1
26|0.886|0.887|1.6e-11|4.6e-06|1.5e-01| 1.936927e+02  1.935393e+02| 0:0:00| chol  1  1
27|1.000|0.146|9.4e-12|3.9e-06|1.3e-01| 1.936910e+02  1.935605e+02| 0:0:00| chol  1  1
```

```
28|1.000|0.340|8.3e-12|2.6e-06|8.9e-02| 1.936906e+02  1.936029e+02| 0:0:00| chol  1  1
29|1.000|0.369|5.1e-12|1.6e-06|5.7e-02| 1.936898e+02  1.936339e+02| 0:0:00| chol  1  1
30|1.000|0.402|5.5e-12|9.7e-07|3.4e-02| 1.936893e+02  1.936555e+02| 0:0:00| chol  1  1
31|1.000|0.355|7.4e-12|1.8e-05|2.5e-02| 1.936891e+02  1.936671e+02| 0:0:00| chol  1  1
32|1.000|0.919|1.0e-12|2.6e-05|3.9e-03| 1.936890e+02  1.936866e+02| 0:0:00| chol  1  1
33|0.552|0.939|1.2e-11|4.3e-06|4.8e-04| 1.936889e+02  1.936886e+02| 0:0:00| chol  1  1
34|0.526|0.930|5.2e-12|5.5e-07|1.2e-04| 1.936889e+02  1.936888e+02| 0:0:00| chol  1  1
35|0.528|0.700|3.7e-12|1.4e-07|5.8e-05| 1.936888e+02  1.936888e+02| 0:0:00| chol  1  1
36|0.523|0.676|2.3e-12|7.2e-08|3.1e-05| 1.936888e+02  1.936888e+02| 0:0:00| chol  1  1
37|0.524|0.677|5.7e-12|3.9e-08|1.6e-05| 1.936888e+02  1.936888e+02| 0:0:00| chol  2  1
38|0.524|0.679|1.8e-11|2.1e-08|8.7e-06| 1.936888e+02  1.936888e+02| 0:0:00| chol  2  1
39|0.524|0.679|1.8e-11|1.1e-08|4.6e-06| 1.936888e+02  1.936888e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-----------------------------------------------------------------
 number of iterations   = 39
 primal objective value =  1.93688809e+02
 dual   objective value =  1.93688805e+02
 gap := trace(XZ)       = 4.60e-06
 relative gap           = 1.19e-08
 actual relative gap    = 1.13e-08
 rel. primal infeas (scaled problem)   = 1.80e-11
 rel. dual     "        "       "      = 1.10e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.9e+02, 4.2e+04, 4.7e+04
 norm(A), norm(b), norm(C) = 3.2e+01, 2.0e+02, 6.8e+00
 Total CPU time (secs)  = 0.40
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 3.5e-11  0.0e+00  3.8e-08  0.0e+00  1.1e-08  1.2e-08
-----------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +193.689


Calling SDPT3 4.0: 478 variables, 285 equality constraints
------------------------------------------------------------

 num. of constraints = 285
 dim. of socp   var  = 366,   num. of socp blk  = 100
 dim. of linear var  = 67
 dim. of free   var  = 45 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-----------------------------------------------------------------
 0|0.000|0.000|1.7e+01|1.3e+02|7.4e+07| 4.444000e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.065|0.022|1.6e+01|1.3e+02|1.5e+07| 2.964957e+04 -5.606346e+03| 0:0:00| chol  1  1
 2|0.289|0.825|1.1e+01|2.2e+01|1.3e+06| 3.362138e+04 -2.439574e+04| 0:0:00| chol  1  1
 3|0.917|0.946|9.3e-01|1.3e+00|9.4e+04| 1.318959e+04 -2.195566e+04| 0:0:00| chol  1  1
 4|0.780|0.866|2.0e-01|2.0e-01|2.2e+04| 3.822891e+03 -9.280426e+03| 0:0:00| chol  1  1
 5|0.739|0.337|5.3e-02|1.3e-01|1.0e+04| 1.384296e+03 -6.702344e+03| 0:0:00| chol  1  1
 6|0.875|0.492|6.6e-03|6.9e-02|4.3e+03| 3.874359e+02 -3.664276e+03| 0:0:00| chol  1  1
 7|0.939|0.455|4.0e-04|3.9e-02|2.3e+03| 2.841899e+02 -1.972518e+03| 0:0:00| chol  1  1
 8|0.942|0.574|2.3e-05|1.7e-02|1.0e+03| 2.465591e+02 -7.379287e+02| 0:0:00| chol  1  1
 9|0.375|0.372|1.5e-05|1.0e-02|6.4e+02| 2.371332e+02 -3.935273e+02| 0:0:00| chol  1  1
10|0.346|0.113|9.5e-06|1.2e-02|5.7e+02| 2.291200e+02 -3.291323e+02| 0:0:00| chol  1  1
11|0.361|0.310|6.1e-06|8.3e-03|4.0e+02| 2.222114e+02 -1.730406e+02| 0:0:00| chol  1  1
12|0.519|0.163|2.9e-06|9.1e-03|3.3e+02| 2.129998e+02 -1.155731e+02| 0:0:00| chol  1  1
```

```
13|0.374|0.323|1.8e-06|6.2e-03|2.3e+02| 2.096285e+02 -2.146116e+01| 0:0:00| chol  1  1
14|0.550|0.186|8.3e-07|6.7e-03|1.9e+02| 2.046946e+02  1.655826e+01| 0:0:00| chol  1  1
15|0.425|0.372|4.7e-07|4.2e-03|1.3e+02| 2.028487e+02  7.833583e+01| 0:0:00| chol  1  1
16|0.637|0.248|1.7e-07|3.1e-03|9.5e+01| 1.995066e+02  1.058553e+02| 0:0:00| chol  1  1
17|0.504|0.292|8.5e-08|2.2e-03|6.9e+01| 1.982760e+02  1.304437e+02| 0:0:00| chol  1  1
18|0.569|0.233|3.7e-08|1.7e-03|5.3e+01| 1.970714e+02  1.447990e+02| 0:0:00| chol  1  1
19|0.508|0.276|1.8e-08|1.2e-03|3.9e+01| 1.964261e+02  1.580128e+02| 0:0:00| chol  1  1
20|0.594|0.254|7.3e-09|9.2e-04|2.9e+01| 1.957742e+02  1.670384e+02| 0:0:00| chol  1  1
21|0.643|0.372|2.6e-09|5.8e-04|1.8e+01| 1.952949e+02  1.771135e+02| 0:0:00| chol  1  1
22|0.868|0.406|3.7e-10|3.4e-04|1.1e+01| 1.948518e+02  1.841804e+02| 0:0:00| chol  1  1
23|1.000|0.648|4.6e-11|1.2e-04|3.8e+00| 1.946776e+02  1.909403e+02| 0:0:00| chol  1  1
24|1.000|0.128|9.0e-11|1.4e-04|3.3e+00| 1.946777e+02  1.914042e+02| 0:0:00| chol  1  1
25|1.000|0.932|8.2e-12|9.3e-06|2.3e-01| 1.946457e+02  1.944191e+02| 0:0:00| chol  1  1
26|1.000|0.177|9.8e-12|7.7e-06|1.9e-01| 1.946463e+02  1.944574e+02| 0:0:00| chol  1  1
27|1.000|0.365|8.0e-12|4.9e-06|1.2e-01| 1.946454e+02  1.945226e+02| 0:0:00| chol  1  1
28|0.933|0.378|4.3e-12|3.0e-06|7.8e-02| 1.946439e+02  1.945666e+02| 0:0:00| chol  1  1
29|0.954|0.433|2.4e-12|1.7e-06|4.5e-02| 1.946431e+02  1.945986e+02| 0:0:00| chol  1  1
30|0.912|0.356|1.4e-12|3.2e-05|3.3e-02| 1.946427e+02  1.946138e+02| 0:0:00| chol  1  1
31|1.000|0.918|7.8e-13|3.6e-05|5.1e-03| 1.946425e+02  1.946392e+02| 0:0:00| chol  1  1
32|0.568|0.934|4.9e-13|5.9e-06|6.8e-04| 1.946424e+02  1.946419e+02| 0:0:00| chol  1  1
33|0.533|0.927|4.3e-12|8.1e-07|1.7e-04| 1.946423e+02  1.946421e+02| 0:0:00| chol  1  1
34|0.531|0.682|5.3e-12|2.2e-07|8.5e-05| 1.946422e+02  1.946422e+02| 0:0:00| chol  1  1
35|0.526|0.661|3.3e-12|1.1e-07|4.5e-05| 1.946422e+02  1.946422e+02| 0:0:00| chol  1  1
36|0.526|0.662|9.6e-13|5.9e-08|2.4e-05| 1.946422e+02  1.946422e+02| 0:0:00| chol  2  1
37|0.527|0.663|2.7e-12|3.2e-08|1.3e-05| 1.946422e+02  1.946422e+02| 0:0:00| chol  2  1
38|0.527|0.664|6.1e-12|1.7e-08|6.7e-06| 1.946422e+02  1.946422e+02| 0:0:00| chol  2  1
39|0.527|0.664|8.5e-13|8.9e-09|3.6e-06| 1.946422e+02  1.946422e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-----------------------------------------------------------------
 number of iterations   = 39
 primal objective value =  1.94642207e+02
 dual   objective value =  1.94642203e+02
 gap := trace(XZ)       = 3.55e-06
 relative gap           = 9.10e-09
 actual relative gap    = 8.70e-09
 rel. primal infeas (scaled problem)   = 8.51e-13
 rel. dual     "        "       "      = 8.93e-09
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.9e+02, 7.3e+04, 8.2e+04
 norm(A), norm(b), norm(C) = 3.2e+01, 2.0e+02, 6.7e+00
 Total CPU time (secs)  = 0.34
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 1.6e-12  0.0e+00  3.0e-08  0.0e+00  8.7e-09  9.1e-09
-----------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +194.642


Calling SDPT3 4.0: 462 variables, 275 equality constraints
------------------------------------------------------------

 num. of constraints = 275
 dim. of socp   var  = 355,   num. of socp blk  = 97
 dim. of linear var  = 65
 dim. of free   var  = 42 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
```

```
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-------------------------------------------------------------------
 0|0.000|0.000|1.7e+01|1.2e+02|6.0e+07| 4.309333e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.075|0.025|1.5e+01|1.1e+02|1.3e+07| 2.835854e+04 -5.505444e+03| 0:0:00| chol  1  1
 2|0.304|0.842|1.1e+01|1.8e+01|1.0e+06| 3.151353e+04 -2.306494e+04| 0:0:00| chol  1  1
 3|0.921|0.950|8.5e-01|9.8e-01|8.0e+04| 1.096483e+04 -2.024913e+04| 0:0:00| chol  1  1
 4|0.764|0.834|2.0e-01|1.9e-01|2.0e+04| 3.448942e+03 -8.689181e+03| 0:0:00| chol  1  1
 5|0.721|0.314|5.6e-02|1.3e-01|1.0e+04| 1.344797e+03 -6.433197e+03| 0:0:00| chol  1  1
 6|0.907|0.434|5.2e-03|7.6e-02|4.5e+03| 3.841791e+02 -3.887052e+03| 0:0:00| chol  1  1
 7|0.913|0.525|4.5e-04|3.7e-02|2.1e+03| 2.863049e+02 -1.818770e+03| 0:0:00| chol  1  1
 8|0.808|0.627|8.6e-05|1.4e-02|8.2e+02| 2.492395e+02 -5.584301e+02| 0:0:00| chol  1  1
 9|0.434|0.233|4.9e-05|1.1e-02|6.3e+02| 2.373285e+02 -3.876921e+02| 0:0:00| chol  1  1
10|0.400|0.140|2.9e-05|1.2e-02|5.5e+02| 2.286021e+02 -3.099253e+02| 0:0:00| chol  1  1
11|0.417|0.351|1.7e-05|7.7e-03|3.7e+02| 2.211728e+02 -1.404206e+02| 0:0:00| chol  1  1
12|0.546|0.183|7.8e-06|8.3e-03|3.0e+02| 2.125064e+02 -8.178563e+01| 0:0:00| chol  1  1
13|0.398|0.340|4.7e-06|5.5e-03|2.1e+02| 2.094458e+02  6.173049e+00| 0:0:00| chol  1  1
14|0.568|0.199|2.0e-06|5.9e-03|1.7e+02| 2.049067e+02  4.179108e+01| 0:0:00| chol  1  1
15|0.448|0.392|1.1e-06|3.6e-03|1.1e+02| 2.031177e+02  9.807701e+01| 0:0:00| chol  1  1
16|0.681|0.284|3.6e-07|2.5e-03|7.6e+01| 1.997573e+02  1.248188e+02| 0:0:00| chol  1  1
17|0.507|0.280|1.8e-07|1.8e-03|5.6e+01| 1.987697e+02  1.437322e+02| 0:0:00| chol  1  1
18|0.562|0.234|7.7e-08|1.4e-03|4.3e+01| 1.978220e+02  1.554669e+02| 0:0:00| chol  1  1
19|0.493|0.283|3.9e-08|1.0e-03|3.1e+01| 1.973265e+02  1.664067e+02| 0:0:00| chol  1  1
20|0.597|0.253|1.6e-08|7.5e-04|2.3e+01| 1.967782e+02  1.736456e+02| 0:0:00| chol  1  1
21|0.621|0.402|6.0e-09|4.5e-04|1.4e+01| 1.963976e+02  1.824132e+02| 0:0:00| chol  1  1
22|0.813|0.444|1.1e-09|2.5e-04|7.8e+00| 1.960484e+02  1.883503e+02| 0:0:00| chol  1  1
23|1.000|0.216|3.7e-10|2.0e-04|6.1e+00| 1.959906e+02  1.899290e+02| 0:0:00| chol  1  1
24|0.984|0.819|3.3e-11|3.6e-05|1.1e+00| 1.958944e+02  1.947989e+02| 0:0:00| chol  1  1
25|1.000|0.279|4.4e-11|2.6e-05|8.1e-01| 1.958942e+02  1.950963e+02| 0:0:00| chol  1  1
26|1.000|0.199|4.6e-11|2.1e-05|6.5e-01| 1.958943e+02  1.952491e+02| 0:0:00| chol  1  1
27|1.000|0.402|3.6e-11|1.2e-05|4.0e-01| 1.958920e+02  1.954982e+02| 0:0:00| chol  1  1
28|0.946|0.370|2.7e-11|7.7e-06|2.5e-01| 1.958884e+02  1.956383e+02| 0:0:00| chol  1  1
29|1.000|0.415|1.2e-11|4.5e-06|1.5e-01| 1.958867e+02  1.957385e+02| 0:0:00| chol  1  1
30|1.000|0.344|2.0e-11|3.0e-06|9.9e-02| 1.958856e+02  1.957878e+02| 0:0:00| chol  1  1
31|1.000|0.413|2.5e-11|1.7e-06|5.9e-02| 1.958852e+02  1.958270e+02| 0:0:00| chol  1  1
32|1.000|0.343|5.3e-12|1.1e-06|3.9e-02| 1.958848e+02  1.958463e+02| 0:0:00| chol  1  1
33|1.000|0.412|1.2e-11|2.2e-05|2.6e-02| 1.958846e+02  1.958617e+02| 0:0:00| chol  1  1
34|1.000|0.923|4.4e-12|2.9e-05|3.9e-03| 1.958845e+02  1.958821e+02| 0:0:00| chol  1  1
35|0.539|0.940|2.7e-12|4.5e-06|4.6e-04| 1.958844e+02  1.958841e+02| 0:0:00| chol  1  1
36|0.520|0.932|1.5e-12|5.4e-07|1.1e-04| 1.958843e+02  1.958843e+02| 0:0:00| chol  1  1
37|0.527|0.718|1.4e-11|1.4e-07|5.3e-05| 1.958843e+02  1.958843e+02| 0:0:00| chol  1  1
38|0.522|0.690|1.4e-11|7.0e-08|2.8e-05| 1.958843e+02  1.958843e+02| 0:0:00| chol  1  1
39|0.522|0.691|2.9e-11|3.7e-08|1.5e-05| 1.958843e+02  1.958843e+02| 0:0:00| chol  2  1
40|0.523|0.693|8.4e-12|2.0e-08|8.0e-06| 1.958843e+02  1.958843e+02| 0:0:00| chol  2  1
41|0.523|0.693|2.5e-11|1.1e-08|4.3e-06| 1.958843e+02  1.958843e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-------------------------------------------------------------------
 number of iterations   = 41
 primal objective value =  1.95884294e+02
 dual   objective value =  1.95884290e+02
 gap := trace(XZ)       = 4.25e-06
 relative gap           = 1.08e-08
 actual relative gap    = 1.03e-08
 rel. primal infeas (scaled problem)   = 2.45e-11
 rel. dual     "        "       "      = 1.06e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.9e+02, 4.1e+04, 4.6e+04
 norm(A), norm(b), norm(C) = 3.1e+01, 2.0e+02, 6.7e+00
 Total CPU time (secs)  = 0.47
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 4.7e-11  0.0e+00  3.5e-08  0.0e+00  1.0e-08  1.1e-08
-------------------------------------------------------------------
```

```
-----------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +195.884


Calling SDPT3 4.0: 449 variables, 268 equality constraints
-----------------------------------------------------------

 num. of constraints = 268
 dim. of socp   var  = 344,   num. of socp blk  = 94
 dim. of linear var  = 63
 dim. of free   var  = 42 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-----------------------------------------------------------------
 0|0.000|0.000|1.6e+01|1.2e+02|6.0e+07| 4.174667e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.072|0.024|1.5e+01|1.2e+02|1.3e+07| 2.760400e+04 -5.406702e+03| 0:0:00| chol  1  1
 2|0.297|0.842|1.0e+01|1.8e+01|1.0e+06| 3.074871e+04 -2.341549e+04| 0:0:00| chol  1  1
 3|0.922|0.953|8.1e-01|9.5e-01|7.8e+04| 1.045265e+04 -2.030968e+04| 0:0:00| chol  1  1
 4|0.754|0.823|2.0e-01|1.9e-01|2.1e+04| 3.429468e+03 -8.737551e+03| 0:0:00| chol  1  1
 5|0.704|0.299|5.9e-02|1.4e-01|1.1e+04| 1.408754e+03 -6.561899e+03| 0:0:00| chol  1  1
 6|0.826|0.394|1.0e-02|8.4e-02|5.2e+03| 5.118712e+02 -4.225020e+03| 0:0:00| chol  1  1
 7|0.947|0.463|5.4e-04|4.7e-02|2.7e+03| 2.884697e+02 -2.304242e+03| 0:0:00| chol  1  1
 8|0.951|0.598|2.7e-05|1.9e-02|1.1e+03| 2.525287e+02 -8.285574e+02| 0:0:00| chol  1  1
 9|0.593|0.448|1.1e-05|1.1e-02|6.2e+02| 2.371621e+02 -3.710037e+02| 0:0:00| chol  1  1
10|0.299|0.147|7.6e-06|1.2e-02|5.3e+02| 2.311177e+02 -2.904900e+02| 0:0:00| chol  1  1
11|0.347|0.279|5.0e-06|8.4e-03|3.9e+02| 2.250574e+02 -1.606249e+02| 0:0:00| chol  1  1
12|0.486|0.148|2.6e-06|9.4e-03|3.3e+02| 2.171149e+02 -1.099751e+02| 0:0:00| chol  1  1
13|0.421|0.379|1.5e-06|5.8e-03|2.2e+02| 2.126965e+02  5.644875e-01| 0:0:00| chol  1  1
14|0.562|0.188|6.5e-07|6.3e-03|1.7e+02| 2.074529e+02  3.556357e+01| 0:0:00| chol  1  1
15|0.421|0.371|3.8e-07|4.0e-03|1.2e+02| 2.056352e+02  9.136571e+01| 0:0:00| chol  1  1
16|0.621|0.230|1.4e-07|3.1e-03|8.9e+01| 2.024820e+02  1.145485e+02| 0:0:00| chol  1  1
17|0.516|0.305|6.9e-08|2.1e-03|6.4e+01| 2.011360e+02  1.385284e+02| 0:0:00| chol  1  1
18|0.539|0.210|3.2e-08|1.7e-03|5.1e+01| 2.000631e+02  1.502690e+02| 0:0:00| chol  1  1
19|0.519|0.310|1.5e-08|1.2e-03|3.6e+01| 1.993288e+02  1.642320e+02| 0:0:00| chol  1  1
20|0.665|0.300|5.1e-09|8.1e-04|2.5e+01| 1.984713e+02  1.739612e+02| 0:0:00| chol  1  1
21|0.545|0.273|2.4e-09|5.9e-04|1.8e+01| 1.982132e+02  1.801161e+02| 0:0:00| chol  1  1
22|0.858|0.313|4.0e-10|4.1e-04|1.2e+01| 1.977833e+02  1.854497e+02| 0:0:00| chol  1  1
23|1.000|0.327|2.8e-10|2.7e-04|8.5e+00| 1.976757e+02  1.892657e+02| 0:0:00| chol  1  1
24|1.000|0.672|3.8e-11|9.0e-05|2.8e+00| 1.975247e+02  1.947669e+02| 0:0:00| chol  1  1
25|1.000|0.347|4.4e-11|5.9e-05|1.8e+00| 1.975192e+02  1.956974e+02| 0:0:00| chol  1  1
26|1.000|0.239|3.7e-11|4.5e-05|1.4e+00| 1.975147e+02  1.961164e+02| 0:0:00| chol  1  1
27|1.000|0.413|2.9e-11|2.6e-05|8.5e-01| 1.975100e+02  1.966723e+02| 0:0:00| chol  1  1
28|0.964|0.360|5.9e-11|1.7e-05|5.5e-01| 1.975024e+02  1.969620e+02| 0:0:00| chol  1  1
29|1.000|0.428|3.7e-11|9.6e-06|3.2e-01| 1.974991e+02  1.971851e+02| 0:0:00| chol  1  1
30|1.000|0.346|3.2e-11|6.3e-06|2.1e-01| 1.974967e+02  1.972900e+02| 0:0:00| chol  1  1
31|1.000|0.428|3.3e-11|3.6e-06|1.2e-01| 1.974958e+02  1.973756e+02| 0:0:00| chol  1  2
32|1.000|0.345|6.6e-12|2.3e-06|8.0e-02| 1.974949e+02  1.974157e+02| 0:0:00| chol  2  1
33|1.000|0.427|5.3e-11|1.3e-06|4.7e-02| 1.974946e+02  1.974485e+02| 0:0:00| chol  1  1
34|1.000|0.343|8.3e-11|2.7e-05|3.5e-02| 1.974942e+02  1.974638e+02| 0:0:00| chol  1  1
35|1.000|0.919|1.4e-11|3.9e-05|5.4e-03| 1.974942e+02  1.974909e+02| 0:0:00| chol  1  1
36|0.540|0.940|7.0e-12|6.4e-06|6.6e-04| 1.974940e+02  1.974936e+02| 0:0:00| chol  1  1
37|0.520|0.931|3.0e-12|8.0e-07|1.6e-04| 1.974940e+02  1.974938e+02| 0:0:00| chol  1  1
38|0.527|0.718|6.7e-13|2.1e-07|7.6e-05| 1.974939e+02  1.974938e+02| 0:0:00| chol  2  1
39|0.522|0.689|1.4e-11|1.0e-07|4.0e-05| 1.974939e+02  1.974939e+02| 0:0:00| chol  1  1
40|0.523|0.691|4.8e-12|5.5e-08|2.1e-05| 1.974939e+02  1.974939e+02| 0:0:00| chol  2  1
41|0.523|0.693|1.2e-11|2.9e-08|1.1e-05| 1.974939e+02  1.974939e+02| 0:0:00| chol  1  1
42|0.523|0.694|3.0e-12|1.6e-08|6.0e-06| 1.974939e+02  1.974939e+02| 0:0:00| chol  2  1
43|0.524|0.693|1.4e-11|8.3e-09|3.2e-06| 1.974939e+02  1.974939e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
```

```
-----------------------------------------------------------------
 number of iterations   = 43
 primal objective value =  1.97493879e+02
 dual   objective value =  1.97493876e+02
 gap := trace(XZ)       = 3.19e-06
 relative gap           = 8.06e-09
 actual relative gap    = 7.68e-09
 rel. primal infeas (scaled problem)   = 1.39e-11
 rel. dual     "        "       "      = 8.33e-09
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.8e+02, 1.1e+05, 1.2e+05
 norm(A), norm(b), norm(C) = 3.1e+01, 2.0e+02, 6.6e+00
 Total CPU time (secs)  = 0.49
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 2.7e-11  0.0e+00  2.7e-08  0.0e+00  7.7e-09  8.1e-09
-----------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +197.494


Calling SDPT3 4.0: 433 variables, 258 equality constraints
------------------------------------------------------------

 num. of constraints = 258
 dim. of socp   var  = 333,   num. of socp blk  = 91
 dim. of linear var  = 61
 dim. of free   var  = 39 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-----------------------------------------------------------------
 0|0.000|0.000|1.6e+01|1.1e+02|4.8e+07| 4.040000e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.084|0.028|1.4e+01|1.0e+02|1.0e+07| 2.628550e+04 -5.311351e+03| 0:0:00| chol  1  1
 2|0.315|0.851|9.9e+00|1.6e+01|8.7e+05| 2.864356e+04 -2.189888e+04| 0:0:00| chol  1  1
 3|0.921|0.956|7.8e-01|7.8e-01|6.9e+04| 9.027913e+03 -1.867418e+04| 0:0:00| chol  1  1
 4|0.739|0.788|2.0e-01|1.9e-01|2.0e+04| 3.171534e+03 -8.381021e+03| 0:0:00| chol  1  1
 5|0.689|0.291|6.3e-02|1.4e-01|1.0e+04| 1.366582e+03 -6.328131e+03| 0:0:00| chol  1  1
 6|0.750|0.384|1.6e-02|8.5e-02|5.4e+03| 5.906421e+02 -4.116926e+03| 0:0:00| chol  1  1
 7|0.944|0.429|8.8e-04|5.1e-02|2.8e+03| 2.853374e+02 -2.409604e+03| 0:0:00| chol  1  1
 8|0.841|0.591|1.4e-04|2.1e-02|1.2e+03| 2.591193e+02 -8.957269e+02| 0:0:00| chol  1  1
 9|0.630|0.494|5.2e-05|1.1e-02|6.0e+02| 2.403220e+02 -3.553227e+02| 0:0:00| chol  1  1
10|0.413|0.134|3.0e-05|1.2e-02|5.2e+02| 2.317843e+02 -2.839015e+02| 0:0:00| chol  1  1
11|0.394|0.346|1.8e-05|7.8e-03|3.5e+02| 2.253420e+02 -1.238505e+02| 0:0:00| chol  1  1
12|0.534|0.173|8.5e-06|8.5e-03|2.9e+02| 2.171378e+02 -7.053942e+01| 0:0:00| chol  1  1
13|0.438|0.392|4.8e-06|5.2e-03|1.9e+02| 2.132018e+02  2.941365e+01| 0:0:00| chol  1  1
14|0.571|0.195|2.1e-06|5.6e-03|1.5e+02| 2.085481e+02  6.081447e+01| 0:0:00| chol  1  1
15|0.437|0.383|1.2e-06|3.4e-03|9.8e+01| 2.068403e+02  1.103296e+02| 0:0:00| chol  1  1
16|0.654|0.262|4.0e-07|2.5e-03|7.2e+01| 2.037236e+02  1.327276e+02| 0:0:00| chol  1  1
17|0.495|0.296|2.0e-07|1.8e-03|5.2e+01| 2.027315e+02  1.514518e+02| 0:0:00| chol  1  1
18|0.539|0.208|9.3e-08|1.4e-03|4.1e+01| 2.018229e+02  1.609693e+02| 0:0:00| chol  1  1
19|0.532|0.339|4.4e-08|9.3e-04|2.8e+01| 2.011510e+02  1.735164e+02| 0:0:00| chol  1  1
20|0.727|0.371|1.2e-08|5.9e-04|1.7e+01| 2.002873e+02  1.830456e+02| 0:0:00| chol  1  1
21|0.682|0.493|3.8e-09|3.0e-04|8.9e+00| 1.999440e+02  1.911158e+02| 0:0:00| chol  1  1
22|0.772|0.300|8.8e-10|2.1e-04|6.2e+00| 1.997529e+02  1.936379e+02| 0:0:00| chol  1  1
23|1.000|0.622|7.6e-11|7.9e-05|2.3e+00| 1.996519e+02  1.973443e+02| 0:0:00| chol  1  1
24|1.000|0.123|1.7e-10|6.9e-05|2.1e+00| 1.996605e+02  1.976189e+02| 0:0:00| chol  1  1
25|1.000|0.863|1.7e-11|9.4e-06|2.9e-01| 1.996331e+02  1.993506e+02| 0:0:00| chol  1  1
```

```
26|1.000|0.127|3.2e-11|8.2e-06|2.5e-01| 1.996351e+02  1.993848e+02| 0:0:00| chol  1  1
27|1.000|0.367|3.3e-11|5.2e-06|1.7e-01| 1.996343e+02  1.994713e+02| 0:0:00| chol  1  1
28|0.939|0.381|1.5e-11|3.2e-06|1.0e-01| 1.996320e+02  1.995299e+02| 0:0:00| chol  1  1
29|0.943|0.425|9.7e-12|1.9e-06|6.0e-02| 1.996308e+02  1.995712e+02| 0:0:00| chol  1  1
30|0.914|0.355|5.1e-12|1.2e-06|3.9e-02| 1.996302e+02  1.995914e+02| 0:0:00| chol  1  1
31|1.000|0.401|9.1e-12|2.0e-05|2.7e-02| 1.996299e+02  1.996064e+02| 0:0:00| chol  1  1
32|1.000|0.920|2.1e-12|3.0e-05|4.2e-03| 1.996297e+02  1.996272e+02| 0:0:00| chol  1  1
33|0.559|0.939|3.4e-12|5.0e-06|5.4e-04| 1.996296e+02  1.996293e+02| 0:0:00| chol  1  1
34|0.526|0.930|8.4e-13|6.6e-07|1.3e-04| 1.996295e+02  1.996294e+02| 0:0:00| chol  1  2
35|0.530|0.706|2.4e-12|1.8e-07|6.5e-05| 1.996295e+02  1.996294e+02| 0:0:00| chol  2  2
36|0.526|0.681|3.1e-12|9.0e-08|3.5e-05| 1.996295e+02  1.996295e+02| 0:0:00| chol  2  1
37|0.526|0.683|3.2e-11|4.8e-08|1.8e-05| 1.996295e+02  1.996295e+02| 0:0:00| chol  2  1
38|0.526|0.685|3.6e-11|2.6e-08|9.8e-06| 1.996295e+02  1.996295e+02| 0:0:00| chol  2  2
39|0.527|0.685|1.7e-11|1.4e-08|5.2e-06| 1.996295e+02  1.996295e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-----------------------------------------------------------------
 number of iterations   = 39
 primal objective value =  1.99629477e+02
 dual   objective value =  1.99629472e+02
 gap := trace(XZ)       = 5.19e-06
 relative gap           = 1.30e-08
 actual relative gap    = 1.24e-08
 rel. primal infeas (scaled problem)   = 1.68e-11
 rel. dual     "        "       "      = 1.38e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.8e+02, 3.3e+04, 3.6e+04
 norm(A), norm(b), norm(C) = 3.0e+01, 1.9e+02, 6.5e+00
 Total CPU time (secs)  = 0.36
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 3.2e-11  0.0e+00  4.5e-08  0.0e+00  1.2e-08  1.3e-08
-----------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +199.629


Calling SDPT3 4.0: 420 variables, 251 equality constraints
------------------------------------------------------------

 num. of constraints = 251
 dim. of socp   var  = 322,   num. of socp blk  = 88
 dim. of linear var  = 59
 dim. of free   var  = 39 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-----------------------------------------------------------------
 0|0.000|0.000|1.5e+01|1.1e+02|4.8e+07| 3.905333e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.081|0.027|1.4e+01|1.1e+02|1.0e+07| 2.556673e+04 -5.219559e+03| 0:0:00| chol  1  1
 2|0.310|0.855|9.6e+00|1.6e+01|8.6e+05| 2.790191e+04 -2.227439e+04| 0:0:00| chol  1  1
 3|0.921|0.959|7.5e-01|7.2e-01|6.8e+04| 8.489611e+03 -1.870433e+04| 0:0:00| chol  1  1
 4|0.730|0.771|2.0e-01|1.9e-01|2.0e+04| 3.112570e+03 -8.513164e+03| 0:0:00| chol  1  1
 5|0.681|0.283|6.5e-02|1.4e-01|1.1e+04| 1.378507e+03 -6.465099e+03| 0:0:00| chol  1  1
 6|0.700|0.375|1.9e-02|8.7e-02|5.7e+03| 6.560230e+02 -4.233208e+03| 0:0:00| chol  1  1
 7|0.937|0.422|1.2e-03|5.4e-02|2.9e+03| 2.839074e+02 -2.516736e+03| 0:0:00| chol  1  1
 8|0.849|0.552|1.9e-04|2.4e-02|1.3e+03| 2.623340e+02 -1.052110e+03| 0:0:00| chol  1  1
 9|0.726|0.602|5.1e-05|9.7e-03|5.4e+02| 2.400683e+02 -2.940027e+02| 0:0:00| chol  1  1
10|0.373|0.116|3.2e-05|1.1e-02|4.8e+02| 2.332153e+02 -2.390394e+02| 0:0:00| chol  1  1
```

```
11|0.348|0.311|2.1e-05|7.6e-03|3.4e+02| 2.281512e+02 -1.094944e+02| 0:0:00| chol  1  1
12|0.516|0.162|1.0e-05|8.4e-03|2.9e+02| 2.206167e+02 -6.172820e+01| 0:0:00| chol  1  1
13|0.459|0.413|5.5e-06|4.9e-03|1.8e+02| 2.162575e+02  4.159492e+01| 0:0:00| chol  1  1
14|0.589|0.204|2.3e-06|3.9e-03|1.4e+02| 2.113076e+02  7.262597e+01| 0:0:00| chol  1  1
15|0.438|0.248|1.3e-06|3.0e-03|1.1e+02| 2.096443e+02  1.025715e+02| 0:0:00| chol  1  1
16|0.504|0.189|6.3e-07|3.2e-03|8.9e+01| 2.078170e+02  1.202370e+02| 0:0:00| chol  1  1
17|0.477|0.415|3.3e-07|1.9e-03|5.5e+01| 2.065462e+02  1.523763e+02| 0:0:00| chol  1  1
18|0.635|0.246|1.2e-07|1.4e-03|4.1e+01| 2.049080e+02  1.641607e+02| 0:0:00| chol  1  1
19|0.513|0.313|5.8e-08|9.7e-04|2.9e+01| 2.042907e+02  1.755896e+02| 0:0:00| chol  1  1
20|0.657|0.301|2.0e-08|6.8e-04|2.0e+01| 2.034987e+02  1.834862e+02| 0:0:00| chol  1  1
21|0.723|0.546|5.5e-09|3.1e-04|9.3e+00| 2.029711e+02  1.937825e+02| 0:0:00| chol  1  1
22|0.873|0.525|7.1e-10|1.5e-04|4.3e+00| 2.026686e+02  1.983862e+02| 0:0:00| chol  1  1
23|1.000|0.671|4.7e-11|4.8e-05|1.4e+00| 2.025984e+02  2.011994e+02| 0:0:00| chol  1  1
24|1.000|0.060|1.9e-10|4.5e-05|1.4e+00| 2.026117e+02  2.012795e+02| 0:0:00| chol  1  1
25|1.000|0.842|4.2e-11|7.1e-06|2.2e-01| 2.025900e+02  2.023761e+02| 0:0:00| chol  1  1
26|1.000|0.139|4.3e-11|6.1e-06|1.9e-01| 2.025913e+02  2.024039e+02| 0:0:00| chol  1  1
27|1.000|0.396|3.1e-11|3.7e-06|1.2e-01| 2.025894e+02  2.024730e+02| 0:0:00| chol  1  1
28|0.857|0.405|1.7e-11|2.2e-06|7.1e-02| 2.025876e+02  2.025174e+02| 0:0:00| chol  1  1
29|0.840|0.412|1.5e-11|1.3e-06|4.2e-02| 2.025867e+02  2.025448e+02| 0:0:00| chol  1  1
30|0.848|0.328|5.1e-12|2.3e-05|3.2e-02| 2.025862e+02  2.025579e+02| 0:0:00| chol  1  1
31|1.000|0.914|4.1e-12|3.8e-05|5.4e-03| 2.025860e+02  2.025826e+02| 0:0:00| chol  1  1
32|0.559|0.938|2.9e-12|6.7e-06|7.1e-04| 2.025858e+02  2.025853e+02| 0:0:00| chol  1  1
33|0.529|0.928|1.4e-11|9.2e-07|1.8e-04| 2.025857e+02  2.025856e+02| 0:0:00| chol  2  2
34|0.531|0.698|8.5e-12|2.6e-07|9.0e-05| 2.025857e+02  2.025856e+02| 0:0:00| chol  2  2
35|0.526|0.675|9.3e-12|1.3e-07|4.8e-05| 2.025856e+02  2.025856e+02| 0:0:00| chol  1  2
36|0.526|0.676|1.1e-11|7.0e-08|2.5e-05| 2.025856e+02  2.025856e+02| 0:0:00| chol  2  2
37|0.527|0.678|1.0e-11|3.7e-08|1.3e-05| 2.025856e+02  2.025856e+02| 0:0:00| chol  2  2
38|0.527|0.678|9.3e-12|2.0e-08|7.1e-06| 2.025856e+02  2.025856e+02| 0:0:00| chol  2  2
39|0.527|0.678|7.6e-12|1.1e-08|3.8e-06| 2.025856e+02  2.025856e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-----------------------------------------------------------------
 number of iterations   = 39
 primal objective value =  2.02585620e+02
 dual   objective value =  2.02585616e+02
 gap := trace(XZ)       = 3.77e-06
 relative gap           = 9.29e-09
 actual relative gap    = 8.76e-09
 rel. primal infeas (scaled problem)   = 7.65e-12
 rel. dual     "        "       "      = 1.05e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.8e+02, 2.5e+04, 2.7e+04
 norm(A), norm(b), norm(C) = 3.0e+01, 1.9e+02, 6.4e+00
 Total CPU time (secs)  = 0.40
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 1.5e-11  0.0e+00  3.4e-08  0.0e+00  8.8e-09  9.3e-09
-----------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +202.586


Calling SDPT3 4.0: 404 variables, 241 equality constraints
------------------------------------------------------------

 num. of constraints = 241
 dim. of socp   var  = 311,   num. of socp blk  = 85
 dim. of linear var  = 57
 dim. of free   var  = 36 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
```

```
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-------------------------------------------------------------------
 0|0.000|0.000|1.5e+01|9.8e+01|3.8e+07| 3.770667e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.095|0.032|1.3e+01|9.6e+01|8.1e+06| 2.421217e+04 -5.134350e+03| 0:0:00| chol  1  1
 2|0.333|0.870|9.0e+00|1.3e+01|7.0e+05| 2.578056e+04 -2.084907e+04| 0:0:00| chol  1  1
 3|0.920|0.964|7.2e-01|5.4e-01|5.9e+04| 7.061587e+03 -1.706885e+04| 0:0:00| chol  1  1
 4|0.714|0.717|2.1e-01|1.8e-01|1.9e+04| 2.794346e+03 -8.326901e+03| 0:0:00| chol  1  1
 5|0.658|0.275|7.1e-02|1.3e-01|1.0e+04| 1.325249e+03 -6.340605e+03| 0:0:00| chol  1  1
 6|0.666|0.358|2.4e-02|8.5e-02|5.9e+03| 6.792346e+02 -4.220891e+03| 0:0:00| chol  1  1
 7|0.917|0.431|2.0e-03|5.2e-02|2.9e+03| 2.859749e+02 -2.460148e+03| 0:0:00| chol  1  1
 8|0.900|0.557|2.0e-04|2.4e-02|1.3e+03| 2.601989e+02 -1.014758e+03| 0:0:00| chol  1  1
 9|0.749|0.622|4.9e-05|9.0e-03|5.0e+02| 2.394206e+02 -2.527164e+02| 0:0:00| chol  1  1
10|0.311|0.103|3.4e-05|1.0e-02|4.5e+02| 2.349257e+02 -2.081127e+02| 0:0:00| chol  1  1
11|0.311|0.277|2.3e-05|7.4e-03|3.4e+02| 2.311782e+02 -1.007912e+02| 0:0:00| chol  1  1
12|0.497|0.150|1.2e-05|8.2e-03|2.9e+02| 2.247009e+02 -5.728701e+01| 0:0:00| chol  1  1
13|0.485|0.440|6.1e-06|4.6e-03|1.7e+02| 2.199975e+02  5.320223e+01| 0:0:00| chol  1  1
14|0.613|0.221|2.3e-06|3.6e-03|1.3e+02| 2.148171e+02  8.546932e+01| 0:0:00| chol  1  1
15|0.426|0.244|1.3e-06|2.7e-03|1.0e+02| 2.134089e+02  1.129333e+02| 0:0:00| chol  1  1
16|0.492|0.179|6.8e-07|2.9e-03|8.5e+01| 2.117747e+02  1.286258e+02| 0:0:00| chol  1  1
17|0.490|0.443|3.5e-07|1.6e-03|5.0e+01| 2.104223e+02  1.611729e+02| 0:0:00| chol  1  1
18|0.685|0.286|1.1e-07|1.2e-03|3.5e+01| 2.084885e+02  1.736599e+02| 0:0:00| chol  1  1
19|0.483|0.291|5.7e-08|8.3e-04|2.6e+01| 2.080404e+02  1.827329e+02| 0:0:00| chol  1  1
20|0.531|0.198|2.7e-08|9.0e-04|2.1e+01| 2.076404e+02  1.872186e+02| 0:0:00| chol  1  1
21|0.502|0.423|1.3e-08|5.2e-04|1.3e+01| 2.073719e+02  1.950391e+02| 0:0:00| chol  1  1
22|0.799|0.422|2.6e-09|3.0e-04|7.1e+00| 2.068640e+02  1.998424e+02| 0:0:00| chol  1  1
23|0.923|0.636|2.1e-10|1.1e-04|2.6e+00| 2.066577e+02  2.041118e+02| 0:0:00| chol  1  1
24|1.000|0.114|2.7e-10|1.3e-04|2.3e+00| 2.066550e+02  2.043864e+02| 0:0:00| chol  1  1
25|1.000|0.886|3.1e-11|1.4e-05|2.7e-01| 2.066115e+02  2.063409e+02| 0:0:00| chol  1  1
26|1.000|0.172|5.0e-11|1.2e-05|2.3e-01| 2.066121e+02  2.063833e+02| 0:0:00| chol  1  1
27|1.000|0.464|4.4e-11|6.4e-06|1.3e-01| 2.066082e+02  2.064810e+02| 0:0:00| chol  1  1
28|0.783|0.422|3.0e-11|3.7e-06|7.6e-02| 2.066058e+02  2.065310e+02| 0:0:00| chol  1  1
29|0.773|0.443|1.5e-11|2.0e-06|4.3e-02| 2.066045e+02  2.065621e+02| 0:0:00| chol  1  1
30|0.751|0.312|1.9e-11|3.6e-05|3.3e-02| 2.066039e+02  2.065746e+02| 0:0:00| chol  1  1
31|0.988|0.911|3.2e-12|4.0e-05|5.4e-03| 2.066035e+02  2.065999e+02| 0:0:00| chol  1  1
32|0.559|0.937|1.7e-12|6.8e-06|7.6e-04| 2.066033e+02  2.066028e+02| 0:0:00| chol  1  1
33|0.525|0.927|4.8e-12|9.8e-07|2.0e-04| 2.066032e+02  2.066031e+02| 0:0:00| chol  1  2
34|0.529|0.705|3.0e-12|2.9e-07|1.0e-04| 2.066032e+02  2.066031e+02| 0:0:00| chol  1  1
35|0.525|0.685|2.0e-11|1.5e-07|5.4e-05| 2.066032e+02  2.066031e+02| 0:0:00| chol  2  2
36|0.526|0.687|1.0e-11|7.9e-08|2.9e-05| 2.066032e+02  2.066031e+02| 0:0:00| chol  2  2
37|0.526|0.689|5.9e-12|4.2e-08|1.5e-05| 2.066031e+02  2.066031e+02| 0:0:00| chol  2  2
38|0.526|0.690|4.1e-12|2.3e-08|8.0e-06| 2.066031e+02  2.066031e+02| 0:0:00| chol  2  2
39|0.526|0.690|2.9e-12|1.2e-08|4.3e-06| 2.066031e+02  2.066031e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-------------------------------------------------------------------
 number of iterations   = 39
 primal objective value =  2.06603143e+02
 dual   objective value =  2.06603139e+02
 gap := trace(XZ)       = 4.25e-06
 relative gap           = 1.03e-08
 actual relative gap    = 9.83e-09
 rel. primal infeas (scaled problem)   = 2.92e-12
 rel. dual     "        "       "      = 1.20e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.8e+02, 3.6e+04, 4.1e+04
 norm(A), norm(b), norm(C) = 2.9e+01, 1.9e+02, 6.3e+00
 Total CPU time (secs)  = 0.35
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 5.6e-12  0.0e+00  3.8e-08  0.0e+00  9.8e-09  1.0e-08
-------------------------------------------------------------------
```

```
------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +206.603


Calling SDPT3 4.0: 391 variables, 234 equality constraints
------------------------------------------------------------

 num. of constraints = 234
 dim. of socp   var  = 300,   num. of socp blk  = 82
 dim. of linear var  = 55
 dim. of free   var  = 36 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-------------------------------------------------------------------
 0|0.000|0.000|1.4e+01|1.0e+02|3.8e+07| 3.636000e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.092|0.030|1.3e+01|9.7e+01|8.0e+06| 2.353342e+04 -5.054155e+03| 0:0:00| chol  1  1
 2|0.333|0.862|8.7e+00|1.4e+01|7.0e+05| 2.504857e+04 -2.091358e+04| 0:0:00| chol  1  1
 3|0.918|0.966|7.1e-01|5.6e-01|5.9e+04| 7.056909e+03 -1.701259e+04| 0:0:00| chol  1  1
 4|0.711|0.715|2.1e-01|1.8e-01|1.9e+04| 2.826969e+03 -8.291694e+03| 0:0:00| chol  1  1
 5|0.636|0.270|7.5e-02|1.3e-01|1.1e+04| 1.392200e+03 -6.330977e+03| 0:0:00| chol  1  1
 6|0.619|0.348|2.9e-02|8.9e-02|6.2e+03| 7.544099e+02 -4.246042e+03| 0:0:00| chol  1  1
 7|0.895|0.387|3.0e-03|6.0e-02|3.1e+03| 3.054713e+02 -2.656349e+03| 0:0:00| chol  1  1
 8|0.916|0.549|2.5e-04|2.7e-02|1.4e+03| 2.669573e+02 -1.133370e+03| 0:0:00| chol  1  1
 9|0.836|0.711|4.1e-05|8.0e-03|4.2e+02| 2.406862e+02 -1.738380e+02| 0:0:00| chol  1  1
10|0.242|0.085|3.1e-05|9.3e-03|3.9e+02| 2.381017e+02 -1.434740e+02| 0:0:00| chol  1  1
11|0.265|0.242|2.3e-05|7.1e-03|3.1e+02| 2.355593e+02 -6.490750e+01| 0:0:00| chol  1  1
12|0.468|0.134|1.2e-05|8.0e-03|2.7e+02| 2.302723e+02 -3.052125e+01| 0:0:00| chol  1  1
13|0.508|0.452|6.0e-06|4.4e-03|1.5e+02| 2.253003e+02  7.402572e+01| 0:0:00| chol  1  1
14|0.605|0.220|2.4e-06|3.4e-03|1.2e+02| 2.204870e+02  1.029617e+02| 0:0:00| chol  1  1
15|0.437|0.239|1.3e-06|2.6e-03|9.3e+01| 2.191220e+02  1.274102e+02| 0:0:00| chol  1  1
16|0.489|0.182|6.9e-07|2.8e-03|7.7e+01| 2.176250e+02  1.419117e+02| 0:0:00| chol  1  1
17|0.506|0.443|3.4e-07|1.6e-03|4.5e+01| 2.162396e+02  1.716412e+02| 0:0:00| chol  1  1
18|0.713|0.321|9.7e-08|1.1e-03|3.0e+01| 2.142587e+02  1.843753e+02| 0:0:00| chol  1  1
19|0.594|0.385|3.9e-08|6.6e-04|1.9e+01| 2.135652e+02  1.948866e+02| 0:0:00| chol  1  1
20|0.695|0.331|1.2e-08|4.4e-04|1.3e+01| 2.129916e+02  2.006233e+02| 0:0:00| chol  2  1
21|0.691|0.496|3.8e-09|2.2e-04|6.4e+00| 2.127265e+02  2.064475e+02| 0:0:00| chol  1  1
22|0.817|0.381|7.0e-10|1.4e-04|3.9e+00| 2.125722e+02  2.087416e+02| 0:0:00| chol  1  1
23|1.000|0.487|1.2e-10|7.0e-05|2.0e+00| 2.125213e+02  2.105579e+02| 0:0:00| chol  1  1
24|1.000|0.090|3.1e-10|6.4e-05|1.8e+00| 2.125398e+02  2.107267e+02| 0:0:00| chol  1  1
25|1.000|0.805|5.3e-11|1.2e-05|3.6e-01| 2.125033e+02  2.121446e+02| 0:0:00| chol  1  1
26|1.000|0.126|9.0e-11|1.1e-05|3.3e-01| 2.125067e+02  2.121867e+02| 0:0:00| chol  2  1
27|1.000|0.832|6.9e-11|1.8e-06|5.5e-02| 2.124968e+02  2.124426e+02| 0:0:00| chol  1  1
28|1.000|0.099|2.0e-11|1.7e-06|5.2e-02| 2.124978e+02  2.124475e+02| 0:0:00| chol  2  1
29|0.886|0.486|1.7e-11|8.5e-07|2.7e-02| 2.124967e+02  2.124699e+02| 0:0:00| chol  2  1
30|0.735|0.412|1.7e-11|1.2e-05|1.8e-02| 2.124961e+02  2.124801e+02| 0:0:00| chol  1  1
31|0.802|0.910|4.5e-12|2.3e-05|3.5e-03| 2.124957e+02  2.124936e+02| 0:0:00| chol  1  1
32|0.587|0.931|2.1e-12|4.6e-06|6.0e-04| 2.124956e+02  2.124951e+02| 0:0:00| chol  1  1
33|0.527|0.922|1.7e-12|8.2e-07|1.8e-04| 2.124955e+02  2.124953e+02| 0:0:00| chol  1  2
34|0.531|0.716|3.2e-12|2.6e-07|8.8e-05| 2.124954e+02  2.124954e+02| 0:0:00| chol  1  2
35|0.527|0.697|4.9e-12|1.3e-07|4.7e-05| 2.124954e+02  2.124954e+02| 0:0:00| chol  2  2
36|0.528|0.699|5.8e-12|7.2e-08|2.5e-05| 2.124954e+02  2.124954e+02| 0:0:00| chol  2  2
37|0.528|0.700|6.1e-12|3.8e-08|1.3e-05| 2.124954e+02  2.124954e+02| 0:0:00| chol  2  2
38|0.528|0.700|5.0e-12|2.0e-08|7.0e-06| 2.124954e+02  2.124954e+02| 0:0:00| chol  2  2
39|0.528|0.700|4.3e-12|1.1e-08|3.7e-06| 2.124954e+02  2.124954e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
-------------------------------------------------------------------
 number of iterations   = 39
 primal objective value =  2.12495400e+02
 dual   objective value =  2.12495396e+02
```

```
 gap := trace(XZ)       = 3.68e-06
 relative gap           = 8.64e-09
 actual relative gap    = 8.16e-09
 rel. primal infeas (scaled problem)   = 4.31e-12
 rel. dual     "        "       "      = 1.08e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.7e+02, 2.4e+04, 2.7e+04
 norm(A), norm(b), norm(C) = 2.9e+01, 1.9e+02, 6.2e+00
 Total CPU time (secs)  = 0.39
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 8.3e-12  0.0e+00  3.3e-08  0.0e+00  8.2e-09  8.6e-09
------------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +212.495


Calling SDPT3 4.0: 375 variables, 224 equality constraints
------------------------------------------------------------

 num. of constraints = 224
 dim. of socp   var  = 289,   num. of socp blk  = 79
 dim. of linear var  = 53
 dim. of free   var  = 33 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-------------------------------------------------------------------
 0|0.000|0.000|1.4e+01|8.9e+01|2.9e+07| 3.501333e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.109|0.036|1.3e+01|8.6e+01|6.3e+06| 2.213175e+04 -4.985082e+03| 0:0:00| chol  1  1
 2|0.365|0.878|8.0e+00|1.1e+01|5.6e+05| 2.287482e+04 -1.943773e+04| 0:0:00| chol  1  1
 3|0.914|0.972|6.8e-01|4.0e-01|5.1e+04| 5.806466e+03 -1.531894e+04| 0:0:00| chol  1  1
 4|0.698|0.655|2.1e-01|1.6e-01|1.8e+04| 2.479293e+03 -8.030538e+03| 0:0:00| chol  1  1
 5|0.619|0.262|7.8e-02|1.2e-01|1.0e+04| 1.291042e+03 -6.147359e+03| 0:0:00| chol  1  1
 6|0.588|0.335|3.2e-02|8.1e-02|6.2e+03| 7.468578e+02 -4.151544e+03| 0:0:00| chol  1  1
 7|0.779|0.311|7.1e-03|6.2e-02|3.6e+03| 3.864264e+02 -2.895673e+03| 0:0:00| chol  1  1
 8|0.655|0.479|2.5e-03|3.3e-02|1.9e+03| 3.114296e+02 -1.479728e+03| 0:0:00| chol  1  1
 9|0.939|0.310|1.5e-04|2.4e-02|1.3e+03| 2.630912e+02 -9.805685e+02| 0:0:00| chol  1  1
10|0.967|0.687|5.0e-06|7.4e-03|4.0e+02| 2.414002e+02 -1.560411e+02| 0:0:00| chol  2  1
11|0.319|0.236|3.4e-06|5.7e-03|3.1e+02| 2.393524e+02 -6.972226e+01| 0:0:00| chol  1  1
12|0.267|0.107|2.5e-06|6.3e-03|2.8e+02| 2.377243e+02 -4.013905e+01| 0:0:00| chol  2  1
13|0.329|0.292|1.7e-06|4.5e-03|2.1e+02| 2.357501e+02  3.246057e+01| 0:0:00| chol  2  1
14|0.503|0.149|8.3e-07|4.9e-03|1.8e+02| 2.323581e+02  5.938664e+01| 0:0:00| chol  1  1
15|0.484|0.457|4.3e-07|2.7e-03|1.0e+02| 2.297980e+02  1.307694e+02| 0:0:00| chol  2  1
16|0.546|0.172|1.9e-07|2.9e-03|8.4e+01| 2.274941e+02  1.455919e+02| 0:0:00| chol  2  1
17|0.453|0.413|1.1e-07|1.7e-03|5.2e+01| 2.265452e+02  1.754118e+02| 0:0:00| chol  1  1
18|0.557|0.183|4.7e-08|1.9e-03|4.3e+01| 2.254606e+02  1.834205e+02| 0:0:00| chol  2  1
19|0.541|0.473|2.2e-08|1.0e-03|2.4e+01| 2.245731e+02  2.008701e+02| 0:0:00| chol  1  2
20|0.794|0.409|4.5e-09|5.9e-04|1.4e+01| 2.231915e+02  2.095070e+02| 0:0:00| chol  1  1
21|0.771|0.396|1.0e-09|3.6e-04|8.4e+00| 2.227807e+02  2.144981e+02| 0:0:00| chol  2  1
22|1.000|0.171|4.3e-10|3.9e-04|7.0e+00| 2.226520e+02  2.157976e+02| 0:0:00| chol  2  1
23|1.000|0.756|1.1e-10|9.4e-05|1.8e+00| 2.224921e+02  2.207247e+02| 0:0:00| chol  2  1
24|1.000|0.243|1.2e-10|7.1e-05|1.4e+00| 2.224662e+02  2.211172e+02| 0:0:00| chol  2  2
25|1.000|0.816|1.5e-11|1.3e-05|2.5e-01| 2.224199e+02  2.221695e+02| 0:0:00| chol  1  1
26|1.000|0.254|1.1e-11|9.8e-06|1.9e-01| 2.224180e+02  2.222299e+02| 0:0:00| chol  1  1
27|1.000|0.421|1.2e-10|5.7e-06|1.1e-01| 2.224170e+02  2.223052e+02| 0:0:00| chol  2  1
28|0.988|0.348|6.4e-11|3.7e-06|7.5e-02| 2.224153e+02  2.223420e+02| 0:0:00| chol  1  1
29|1.000|0.453|2.6e-11|2.0e-06|4.2e-02| 2.224146e+02  2.223737e+02| 0:0:00| chol  2  1
```

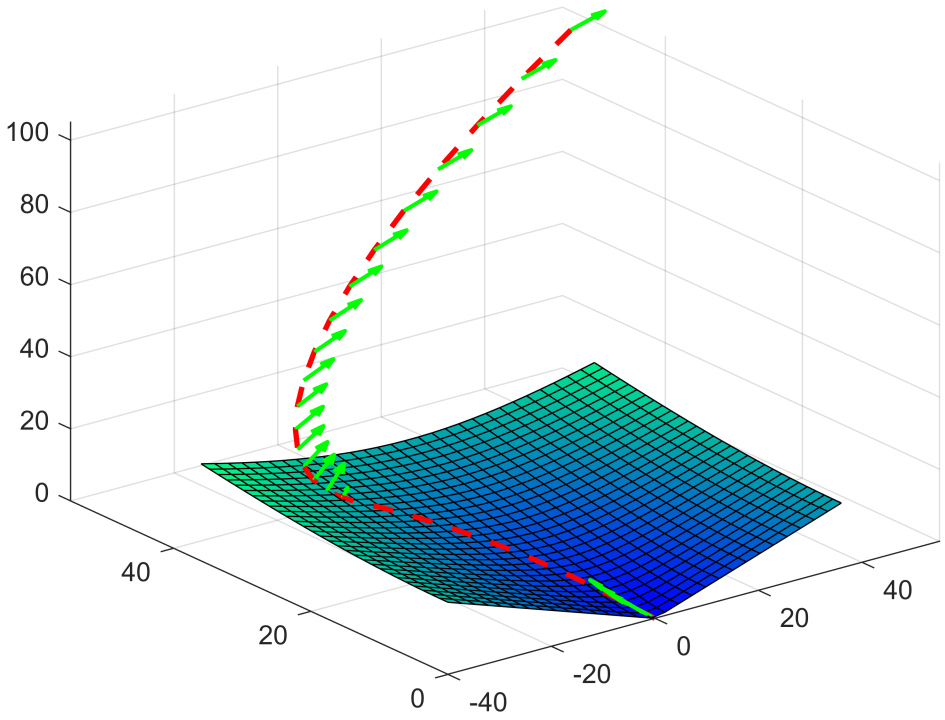
```
30|0.936|0.356|4.7e-11|1.3e-06|2.7e-02| 2.224141e+02  2.223876e+02| 0:0:00| chol  2  2
31|1.000|0.454|7.6e-12|2.0e-05|1.7e-02| 2.224139e+02  2.223991e+02| 0:0:00| chol  1  1
32|0.949|0.923|3.4e-11|2.2e-05|2.5e-03| 2.224137e+02  2.224121e+02| 0:0:00| chol  1  1
33|0.534|0.940|6.6e-12|3.3e-06|3.2e-04| 2.224136e+02  2.224134e+02| 0:0:00| chol  1  1
34|0.522|0.929|7.3e-13|4.3e-07|8.7e-05| 2.224136e+02  2.224135e+02| 0:0:00| chol  1  2
35|0.532|0.743|3.3e-12|1.3e-07|4.3e-05| 2.224135e+02  2.224135e+02| 0:0:00| chol  1  1
36|0.528|0.719|2.1e-11|6.6e-08|2.3e-05| 2.224135e+02  2.224135e+02| 0:0:00| chol  2  2
37|0.528|0.721|1.1e-11|3.5e-08|1.2e-05| 2.224135e+02  2.224135e+02| 0:0:00| chol  2  2
38|0.529|0.723|6.1e-12|1.9e-08|6.5e-06| 2.224135e+02  2.224135e+02| 0:0:00| chol  2  2
39|0.529|0.722|4.1e-12|1.0e-08|3.4e-06| 2.224135e+02  2.224135e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
------------------------------------------------------------------
 number of iterations   = 39
 primal objective value =  2.22413515e+02
 dual   objective value =  2.22413512e+02
 gap := trace(XZ)       = 3.44e-06
 relative gap           = 7.71e-09
 actual relative gap    = 7.26e-09
 rel. primal infeas (scaled problem)   = 4.11e-12
 rel. dual     "        "       "      = 1.00e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.7e+02, 8.5e+04, 9.5e+04
 norm(A), norm(b), norm(C) = 2.8e+01, 1.9e+02, 6.1e+00
 Total CPU time (secs)  = 0.37
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 7.9e-12  0.0e+00  3.1e-08  0.0e+00  7.3e-09  7.7e-09
------------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +222.414


Calling SDPT3 4.0: 362 variables, 217 equality constraints
------------------------------------------------------------

 num. of constraints = 217
 dim. of socp   var  = 278,   num. of socp blk  = 76
 dim. of linear var  = 51
 dim. of free   var  = 33 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
*****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-------------------------------------------------------------------
 0|0.000|0.000|1.3e+01|9.1e+01|2.9e+07| 3.366667e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.106|0.034|1.2e+01|8.8e+01|6.2e+06| 2.149807e+04 -4.922306e+03| 0:0:00| chol  1  1
 2|0.371|0.870|7.6e+00|1.2e+01|5.5e+05| 2.213422e+04 -1.934511e+04| 0:0:00| chol  1  1
 3|0.912|0.973|6.7e-01|4.1e-01|5.0e+04| 5.774827e+03 -1.508669e+04| 0:0:00| chol  1  1
 4|0.695|0.656|2.0e-01|1.6e-01|1.8e+04| 2.499344e+03 -7.847702e+03| 0:0:00| chol  1  1
 5|0.616|0.260|7.8e-02|1.2e-01|1.0e+04| 1.302510e+03 -5.999296e+03| 0:0:00| chol  1  1
 6|0.575|0.331|3.3e-02|8.2e-02|6.2e+03| 7.634825e+02 -4.025460e+03| 0:0:00| chol  1  1
 7|0.703|0.293|9.8e-03|6.4e-02|3.8e+03| 4.305839e+02 -2.843533e+03| 0:0:00| chol  1  1
 8|0.500|0.395|4.9e-03|4.1e-02|2.3e+03| 3.565789e+02 -1.674809e+03| 0:0:00| chol  1  1
 9|0.637|0.228|1.8e-03|3.2e-02|1.7e+03| 3.097230e+02 -1.246778e+03| 0:0:00| chol  1  1
10|0.595|0.331|7.2e-04|2.2e-02|1.1e+03| 2.837998e+02 -7.698204e+02| 0:0:00| chol  1  2
11|0.746|0.251|1.8e-04|1.7e-02|8.3e+02| 2.689649e+02 -5.294764e+02| 0:0:00| chol  2  2
12|0.972|0.766|5.1e-06|3.9e-03|1.9e+02| 2.509684e+02  5.941274e+01| 0:0:00| chol  2  1
13|0.957|0.188|2.2e-07|4.0e-03|1.6e+02| 2.505255e+02  9.270169e+01| 0:0:00| chol  2  1
14|0.094|0.342|2.0e-07|2.6e-03|1.1e+02| 2.505261e+02  1.409987e+02| 0:0:00| chol  2  2
```

```
15|0.439|0.113|1.1e-07|3.0e-03|1.0e+02| 2.503456e+02  1.517020e+02| 0:0:00| chol  2  2
16|0.419|0.270|6.5e-08|2.2e-03|7.7e+01| 2.500798e+02  1.748855e+02| 0:0:00| chol  2  2
17|0.499|0.209|3.3e-08|1.7e-03|6.2e+01| 2.495946e+02  1.883968e+02| 0:0:00| chol  2  2
18|0.493|0.184|1.7e-08|1.8e-03|5.2e+01| 2.490661e+02  1.980509e+02| 0:0:00| chol  2  2
19|0.493|0.393|8.5e-09|1.1e-03|3.4e+01| 2.485022e+02  2.153500e+02| 0:0:00| chol  2  2
20|0.673|0.221|2.8e-09|8.7e-04|2.7e+01| 2.475690e+02  2.215944e+02| 0:0:00| chol  2  2
21|0.921|0.412|5.1e-10|5.1e-04|1.6e+01| 2.465298e+02  2.311260e+02| 0:0:00| chol  2  2
22|1.000|0.282|4.0e-10|3.7e-04|1.1e+01| 2.461160e+02  2.350324e+02| 0:0:00| chol  2  2
23|0.941|0.706|1.6e-10|1.1e-04|3.4e+00| 2.457650e+02  2.424417e+02| 0:0:00| chol  2  2
24|0.826|0.345|9.9e-11|7.1e-05|2.2e+00| 2.456992e+02  2.435260e+02| 0:0:00| chol  2  2
25|1.000|0.278|8.5e-11|5.1e-05|1.6e+00| 2.456849e+02  2.440959e+02| 0:0:00| chol  2  2
26|1.000|0.281|1.1e-10|3.7e-05|1.2e+00| 2.456703e+02  2.445149e+02| 0:0:00| chol  2  2
27|1.000|0.402|1.2e-10|2.2e-05|7.2e-01| 2.456555e+02  2.449512e+02| 0:0:00| chol  2  2
28|1.000|0.352|1.2e-10|1.4e-05|4.7e-01| 2.456444e+02  2.451846e+02| 0:0:00| chol  1  2
29|1.000|0.395|1.2e-10|8.6e-06|2.9e-01| 2.456391e+02  2.453567e+02| 0:0:00| chol  2  2
30|1.000|0.335|1.1e-10|5.7e-06|1.9e-01| 2.456356e+02  2.454464e+02| 0:0:00| chol  2  2
31|1.000|0.388|1.3e-10|3.5e-06|1.2e-01| 2.456338e+02  2.455162e+02| 0:0:00| chol  2  2
32|1.000|0.332|1.1e-10|2.3e-06|8.0e-02| 2.456324e+02  2.455532e+02| 0:0:00| chol  2  2
33|1.000|0.386|1.3e-10|1.4e-06|5.0e-02| 2.456317e+02  2.455823e+02| 0:0:00| chol  2  2
34|1.000|0.330|1.3e-10|9.7e-07|3.4e-02| 2.456312e+02  2.455978e+02| 0:0:00| chol  2  2
35|1.000|0.385|1.3e-10|1.3e-05|2.4e-02| 2.456309e+02  2.456101e+02| 0:0:00| chol  2  2
36|1.000|0.911|1.3e-11|3.1e-05|4.6e-03| 2.456307e+02  2.456280e+02| 0:0:00| chol  2  2
37|0.652|0.931|7.5e-12|6.4e-06|7.2e-04| 2.456305e+02  2.456300e+02| 0:0:00| chol  2  2
38|0.544|0.924|5.6e-12|1.0e-06|2.0e-04| 2.456304e+02  2.456303e+02| 0:0:00| chol  2  2
39|0.544|0.689|4.2e-12|3.1e-07|9.7e-05| 2.456304e+02  2.456303e+02| 0:0:00| chol  2  2
40|0.538|0.668|4.8e-12|1.6e-07|5.1e-05| 2.456304e+02  2.456303e+02| 0:0:00| chol  2  2
41|0.538|0.668|5.6e-12|8.4e-08|2.7e-05| 2.456303e+02  2.456303e+02| 0:0:00| chol  2  2
42|0.539|0.669|6.1e-12|4.5e-08|1.4e-05| 2.456303e+02  2.456303e+02| 0:0:00| chol  2  2
43|0.539|0.667|7.2e-12|2.4e-08|7.6e-06| 2.456303e+02  2.456303e+02| 0:0:00| chol  2  2
44|0.539|0.667|8.7e-12|1.3e-08|4.0e-06| 2.456303e+02  2.456303e+02| 0:0:00|
  stop: max(relative gap, infeasibilities) < 1.49e-08
------------------------------------------------------------------------
 number of iterations   = 44
 primal objective value =  2.45630324e+02
 dual   objective value =  2.45630320e+02
 gap := trace(XZ)       = 4.02e-06
 relative gap           = 8.17e-09
 actual relative gap    = 8.08e-09
 rel. primal infeas (scaled problem)   = 8.71e-12
 rel. dual     "        "       "      = 1.27e-08
 rel. primal infeas (unscaled problem) = 0.00e+00
 rel. dual     "        "       "      = 0.00e+00
 norm(X), norm(y), norm(Z) = 3.7e+02, 2.0e+05, 2.2e+05
 norm(A), norm(b), norm(C) = 2.8e+01, 1.9e+02, 6.0e+00
 Total CPU time (secs)  = 0.47
 CPU time per iteration = 0.01
 termination code       =  0
 DIMACS: 1.7e-11  0.0e+00  3.8e-08  0.0e+00  8.1e-09  8.2e-09
------------------------------------------------------------------------

------------------------------------------------------------
Status: Solved
Optimal value (cvx_optval): +245.63


Calling SDPT3 4.0: 346 variables, 207 equality constraints
------------------------------------------------------------

 num. of constraints = 207
 dim. of socp   var  = 267,   num. of socp blk  = 73
 dim. of linear var  = 49
 dim. of free   var  = 30 *** convert ublk to lblk
*****************************************************************
   SDPT3: Infeasible path-following algorithms
```

```
****************************************************************
 version  predcorr  gam  expon  scale_data
    NT      1      0.000   1        0
it pstep dstep pinfeas dinfeas  gap      prim-obj      dual-obj    cputime
-----------------------------------------------------------------
 0|0.000|0.000|1.3e+01|8.0e+01|2.2e+07| 3.232000e+03  0.000000e+00| 0:0:00| chol  1  1
 1|0.127|0.042|1.2e+01|7.7e+01|4.7e+06| 2.003489e+04 -4.876936e+03| 0:0:00| chol  1  1
 2|0.416|0.889|6.7e+00|8.7e+00|4.3e+05| 1.985855e+04 -1.778138e+04| 0:0:00| chol  1  1
 3|0.907|0.979|6.3e-01|2.8e-01|4.2e+04| 4.649570e+03 -1.326553e+04| 0:0:00| chol  1  1
 4|0.680|0.621|2.0e-01|1.3e-01|1.6e+04| 2.141709e+03 -7.121012e+03| 0:0:00| chol  1  1
 5|0.606|0.249|7.9e-02|9.8e-02|9.4e+03| 1.158361e+03 -5.485633e+03| 0:0:00| chol  1  1
 6|0.533|0.323|3.7e-02|8.2e-02|5.9e+03| 7.287831e+02 -3.669125e+03| 0:0:00| chol  1  1
 7|0.598|0.315|1.5e-02|6.4e-02|3.6e+03| 4.680816e+02 -2.449472e+03| 0:0:00| chol  1  2
 8|0.451|0.336|8.2e-03|4.5e-02|2.4e+03| 3.840004e+02 -1.512008e+03| 0:0:00| chol  1  1
 9|0.407|0.191|4.8e-03|4.6e-02|1.9e+03| 3.490557e+02 -1.057606e+03| 0:0:00| chol  2  2
10|0.2...
```

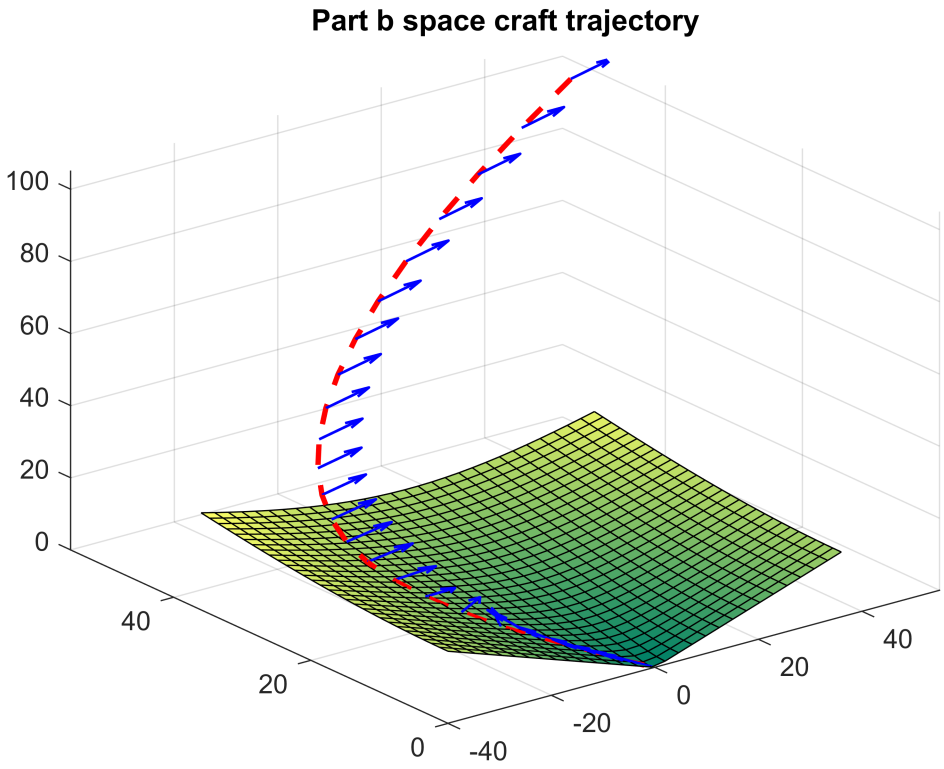
Glide Cone:

```
x = linspace(-40,length(p_minf),30);
y = linspace(0,length(p_minf),30);
[X,Y] = meshgrid(x,y); % Create a Surface from Axis x  and  y
Z = alpha*sqrt(X.^2+Y.^2); % Value oin the 3rd dimension

Fig3=figure();
colormap winter;
surf(X,Y,Z);
axis([-40,55,0,55,0,105]);
grid on;
hold on;
plot3(p_minf(1,:),p_minf(2,:),p_minf(3,:),'r--','linewidth',2);
quiver3(p_minf(1,1:K),p_minf(2,1:K),p_minf(3,1:K),...
                    f_minf(1,:),f_minf(2,:),f_minf(3,:),0.3,'g','linewidth',1.5);
```




```
title('Part a space craft trajectory');
```

```
% plot minimum time trajectory for part (b)
Fig4=figure();
colormap summer;
surf(X,Y,Z);
axis([-40,55,0,55,0,105]);
grid on;
hold on;
plot3(p_mink(1,:),p_mink(2,:),p_mink(3,:),'r--','linewidth',2);
quiver3(p_mink(1,1:Kmin),p_mink(2,1:Kmin),p_mink(3,1:Kmin),...
                        f_mink(1,:),f_mink(2,:),f_mink(3,:),0.3,'b','linewidth',1);
title('Part b space craft trajectory');
```




```
% Reporting minimum touch down Time --From part b ---:
disp(Ki) % Disp K
```

```
    24
```

```
disp(Ki*h)% for h = 1 --> T = K;
```

```
    24
```