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```
% Author: Justice Amoh
% Description: ENGS 104 - Optimization: Assignment 2
% Date: 10/26/2015
```

PROBLEM 1

Linear program in augmented form: $min_x c' * x$ such that $a * x = b, x \geq 0$.

```
% load file a2p1.mat with vars a, b and c.
load data/a2p1.mat
```

Part A

Which feasible solution has the largest value for x_{23} ? $\max(f(x)) = -\min(-f(x))$

```
f = zeros(size(c));
f(23) = -1;

Aeq = a;
beq = b;
lb  = 0;
[x,fval] = linprog(f,[],[],Aeq,beq,lb);
```

Part B

Is there a basic feasible solution involving x_4, x_{12}, x_{23} ? Set x_4, x_{12}, x_{23} to 1, all other unknowns to zero and run LP

```
f = zeros(size(c));
f(4)=1; f(12) = 1; f(23) = 1;

Aeq = a;
```

```
beq = b;
lb  = 0;
[x,fval] = linprog(f,[],[],Aeq,beq,lb);

% *Answer* : Yeah, there is a feasible solution involving just $x_{4},
 x_{12}, x_{23}$
```

Part C

```
f   = c;
Aeq = a;
beq = b;
lb  = 0;
[x,fval] = linprog(f,[],[],Aeq,beq,lb);

Warning: Length of lower bounds is < length(x); filling in missing
 lower bounds
with -Inf.
Exiting: One or more of the residuals, duality gap, or total relative
 error
 has stalled:
         the dual appears to be infeasible (and the primal unbounded).

         (The primal residual < TolFun=1.00e-08.)
Warning: Length of lower bounds is < length(x); filling in missing
 lower bounds
with -Inf.
Exiting: One or more of the residuals, duality gap, or total relative
 error
 has stalled:
         the dual appears to be infeasible (and the primal unbounded).

         (The primal residual < TolFun=1.00e-08.)
Warning: Length of lower bounds is < length(x); filling in missing
 lower bounds
with -Inf.
Exiting: One or more of the residuals, duality gap, or total relative
 error
 has stalled:
         the dual appears to be infeasible (and the primal unbounded).

         (The primal residual < TolFun=1.00e-08.)
```

PROBLEM 2

Part A - Infinity Norm

Question: $\min_y \|y * a - c\|_\infty$

```
aa = a';
bb = c';
```

```
[n,m] = size(aa);
Aineq = [+aa -ones(n,1); ...
         -aa -ones(n,1)];
bineq = [bb ; -bb];

f    = [zeros(1,m) 1];
[x,fval]   = linprog(f,Aineq,bineq,[],[]);   % check dimensionality
fprintf('Linfty Norm - Minimum value is: %.2f \n',fval)
```

Part B - L1 Norm

Question: $\min_u \|u * a - c\|_1$

```
aa = a';
bb = c';

[n,m] = size(aa);
Aineq = [+aa -eye(n); ...
         -aa -eye(n)];
bineq = [+bb ; -bb];

f     = [zeros(1,m) ones(1,n)];
[u,fval]  = linprog(f,Aineq,bineq,[],[]);
fprintf('L1 Norm - Minimum value is: %.2f \n',fval)
x_l1 = u(m+1:end);
```

Part C

Question: $\min_z \|z * a - c\|_2$

```
A = a';
B = c';

z = A' * ((A*A')\ B);
fval = norm((A*z)-B,2);
fprintf('L2 Norm - Minimum value is: %.2f \n',fval);
```

Part D

Question: $\min_w \|w * a - c\|_1 + \|w * a - c\|_\infty$

```
aa = a';
bb = c';

[n,m] = size(aa);
Aineq = [+aa -eye(n) zeros(n,1); ...
         -aa -eye(n) zeros(n,1); ...
         zeros(n,m) eye(n) -ones(n,1)];
bineq = [+bb ; -bb; zeros(n,1)];

f      = [zeros(1,m) ones(1,n) 1];
```

```
[w,fval]  = linprog(f,Aineq,bineq,[],[]);
fprintf('L1 + Infinity Norm - Minimum value is: %.2f \n',fval)
```

```
Optimization terminated.
Linfty Norm - Minimum value is: 4.18
Optimization terminated.
L1 Norm - Minimum value is: 208.14
Warning: Matrix is close to singular or badly scaled. Results may be
inaccurate. RCOND =  1.400618e-19.
L2 Norm - Minimum value is: 299.20
Optimization terminated.
L1 + Infinity Norm - Minimum value is: 215.48
```

PROBLEM 3

Question Solve max-flow problem - Primal

```
Aeq = [ 1 -1  0 -1  0  0  0  0 ; ...
        0  0  0  0 -1  1 -1  0 ; ...
        0  1 -1  0  1  0  0  0 ; ...
        0  0  0  1  0  0  1 -1 ];

[n,m] = size(Aeq);
beq = zeros(n,1);

A = eye(m);
b = [13  5  6  1  7 12  1  4]';

f  = zeros(1,m); f(1)=-1; f(6)=-1;
lb = 0;

[x_primal,fval] = linprog(f,A,b,Aeq,beq,lb);
```

```
Warning: Length of lower bounds is < length(x); filling in missing
 lower bounds
with -Inf.
Optimization terminated.
```

PROBLEM 4

Question Max-flow problem - Dual

```
Aeq = [ 1 -1  0 -1  0  0  0  0 ; ...
        0  0  0  0 -1  1 -1  0 ; ...
        0  1 -1  0  1  0  0  0 ; ...
        0  0  0  1  0  0  1 -1 ];
Aeq = -Aeq';
[n,m] = size(Aeq);

A = eye(m);
c = zeros(n,1); c(1)=-1; c(6)=-1;

b = [13  5  6  1  7 12  1  4]';
```

```
lb = 0;
% [x_dual, fval] = linprog(b,[],[],Aeq,c,lb);
```

PROBLEM 5

Equality Constraints a = @(x) x(1) + x(2) + x(3) -30; b = @(x) x(1)^2 + 2*x(2)^4 +3* x(3)^2 - 2; c = @(x) 2*(x(1)+40)^2 + (x(2)-30)^2 + (x(3)+20)^4 - 1;

```
a = [1 1 1 0 0 0 0 0 0];
b = [0 0 0 1 1 1 0 0 0];
c = [0 0 0 0 0 0 1 1 1];

gfun = @p5con;

f = @(x) norm(a-b,2).^2 + norm(c-b,2).^2 + norm(a-c,2).^2;

x0 = [-2 1 0 1 4 1 1 2 3];
options = optimoptions('fmincon','Algorithm','interior-
point','Display','iter');
[x,fval] = fmincon(f,x0,[],[],[],[],[],[],gfun,options);
```

```
                                            First-order      Norm of
 Iter F-count            f(x)  Feasibility   optimality         step
    0      10    1.800000e+01    2.840e+05    0.000e+00
    1      20    1.800000e+01    9.095e+04    1.033e+01    1.885e+01
    2      30    1.800000e+01    2.990e+04    2.003e+00    4.559e+00
    3      40    1.800000e+01    1.067e+04    8.717e-01    3.720e+00
    4      50    1.800000e+01    4.903e+03    3.278e-01    3.685e+00
    5      60    1.800000e+01    3.930e+03    6.854e-01    7.812e+00
    6      72    1.800000e+01    2.444e+03    7.801e+00    1.129e+01
    7      82    1.800000e+01    7.284e+02    1.018e+00    1.739e+01
    8      92    1.800000e+01    2.387e+02    3.785e-01    1.119e+01
    9     102    1.800000e+01    1.882e+02    1.224e+00    9.942e+00
   10     112    1.800000e+01    1.265e+02    9.893e-01    5.935e+00
   11     122    1.800000e+01    8.233e+01    1.846e+00    7.519e+00
   12     132    1.800000e+01    2.387e+01    7.655e-01    3.713e+00
   13     142    1.800000e+01    6.621e+00    3.128e-01    2.023e+00
   14     152    1.800000e+01    1.774e+00    1.417e-01    1.176e+00
   15     162    1.800000e+01    4.231e-01    6.045e-02    5.907e-01
   16     172    1.800000e+01    6.230e-02    1.820e-02    2.283e-01
   17     182    1.800000e+01    2.305e-03    1.418e-03    4.393e-02
   18     192    1.800000e+01    3.627e-06    1.219e-05    1.744e-03
   19     202    1.800000e+01    7.693e-12    3.860e-09    2.752e-06

Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-
decreasing in
feasible directions, to within the default value of the function
 tolerance,
and constraints are satisfied to within the default value of the
 constraint tolerance.
```

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