ME555 Homework 1 Solution

Problem 1 (40 points)

a) **Excel: (10 points)**

x* = [-0.7674, 0.2558, 0.6279, -0.1163, 0.2558]’
fmin = 4.0930

Matlab: (10 points)

Both x* and fmin should be the same as those in the Excel solution.

Objective function:

```
function f = fun(x);
f = (x(1)-x(2))^2+(x(2)+x(3)-2)^2+(x(4)-1)^2+(x(5)-1)^2;
```

Main file:

```
x0 = ones(5,1);
A = [eye(5); -eye(5)];
b = 10*ones(10,1);
Aeq = [1 3 0 0 0; 0 0 1 1 -2; 0 1 0 0 -1];
beq = zeros(3,1);
[x,fval] = fmincon(@fun, x0, A, b, Aeq, beq);
```

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b) **Excel**: **(10 points)**

x* = [0.6355, 0, 0.3127, 0.0518]’
fmin = 29.8944

Matlab: (10 points)

Both x* and fmin should be the same as those in the Excel solution.

Objective function:

```
function f = fun(x);
f = [24.55, 26.75, 39, 40.5]*x;
```

Nonlinear constraint function:

```
function [c,ceq] = funcon(x);
c = [-12, -11.9, -41.8, -52.1]*x + 21 + 1.645*sqrt(x'*diag([0.28, 0.19, 20.5, 0.62])*x);
ceq = [];
```

Main file:

```
x0 = ones(4,1);
A = [-eye(4); -2.3 -5.6 -11.1 -1.3];
b = [zeros(4,1); -5];
Aeq = ones(4,1);
beq = 1;
lb = zeros(4,1);
ub = [];
[x,fval] = fmincon(@fun, x0, A, b, Aeq, beq, lb, ub, @funcon);
```

Problem 2 (50 points)

a) **Design variables: (5 points)**
r: Radius of the can
h: Height of the can

b) **Objective: (10 points)** minimize the surface area (for fixed thickness)
min $A = 2\pi r^2 + 2\pi rh$

c) **Constraints: (10 points)**
$r \geq 0$
$h \geq 0$
$\pi r^2 h = V$

d) **Assumptions: (5 points)**
- Can is in perfect cylindrical shape.
- Thickness of the material used in production is fixed and same everywhere on the can.
- Thickness of the material is good enough to withstand the internal pressure.
- Thickness of the material will satisfy other manufacturing or packaging constraints.
- …

e) **Optimization Results: (20 points)**
Using a can volume of 330ml = 330000mm^3, the results are:
$r^* = 37.4$ mm
$h^* = 74.9$ mm
$A_{min} = 26436$ mm^2

Real can dimensions:
r = 32 mm
h = 122 mm
Possible reasons for finding different results than the real dimensions:
- Top, bottom, and side thicknesses are not the same. $t_{bottom} > t_{top} > t_{sides}$
- A can is not in a perfect cylindrical shape due to some packaging and (pressure related) engineering constraints.
- A can must also be easy to hold. There needs to be an upper bound on r.
-…