Contents

```
% Paula Burgi
% Midterm 2, Problem 1

clear
close all
```

Part b: Determine S and T

```
% data input
t  = [5 10 20 30 40 50]';
hm = [0.80 0.78 0.54 0.41 0.33 0.27]';

% equation parameters
T = sym('T'); % Trasmissivity (m^2/hr)
S = sym('S'); % Storativity (dimensionless)
Q = 50;       % Water volume in (m^3)
d = 60;       % Dist between wells (m)
s = 0.01;     % Standard deviation (m)
% calculate covariance matrix
n  = length(t);
Cd = eye(n)*(s.^2);
Cdi = inv(sqrt(Cd));

% input functional form of slug test
h1  = Q./(4.*pi.*T.*t);
h2  = exp((-(d.^2).*S)./(4.*T.*t));
hd  = h1.*h2;
% calculate residual between functional form and data
h   = Cdi*(hd-hm);

% calculate Jacobian
fiS = diff(h, S);
fiT = diff(h, T);
J   = [fiS fiT];

% initial guess
S0    = 7e-4;
T0    = .2;
var0  = [S0; T0];

% convergence criteria
ep    = 1e-9;

% Use LM method to calculate T & S
[x, k, Cm, chi2] = LMLSQ(h, var0, J, ep);

disp(['Number of iterations to convergence: ' num2str(k)]);
```

```
Number of iterations to convergence: 10
```

Part c: Sate S and T with STD

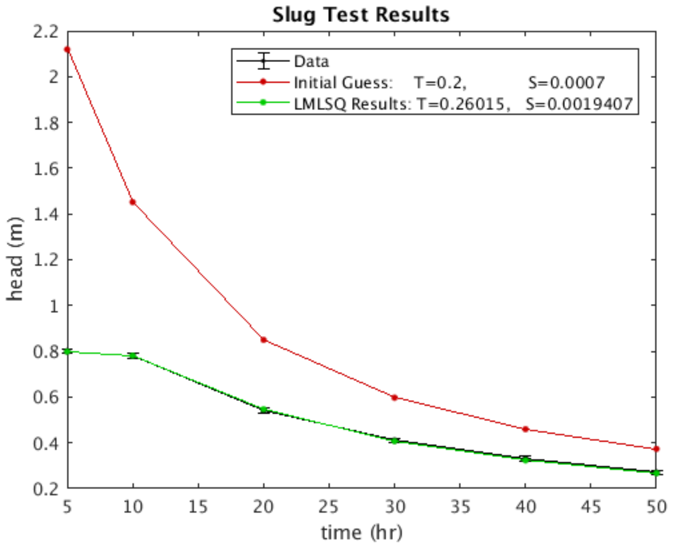
```
% get values of S and T
Sf     = x(1);
Tf     = x(2);
% find uncertainty
sm     = diag(Cm);
Ssig   = sqrt(sm(1));
Tsig   = sqrt(sm(2));

disp(['Calculated T with 1-sigma error: ' num2str(Tf) char(177) num2str(Tsig)]);
disp(['Calculated S with 1-sigma error: ' num2str(Sf) char(177) num2str(Ssig)]);
```

```
Calculated T with 1-sigma error: 0.26015±0.0036874
Calculated S with 1-sigma error: 0.0019407±1.6014e-05
```

Part d: plot

```
figure(1); hold on; box on;
errorbar(t, hm, sqrt(diag(Cd)), '-k.', 'markersize', 10);
T = T0;
S = S0;
```

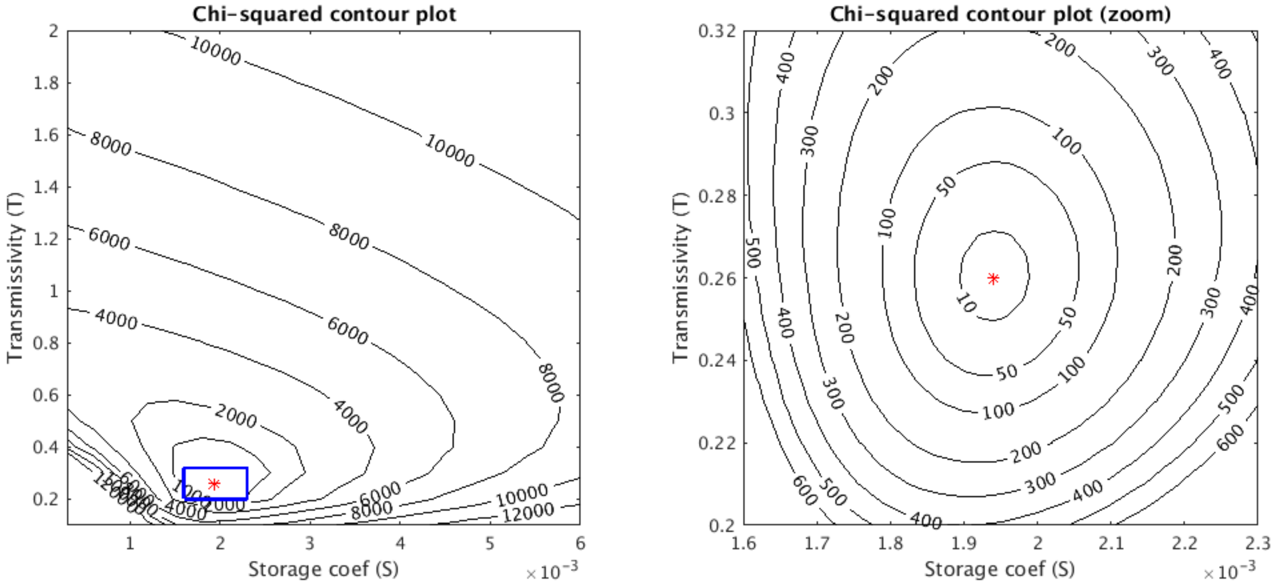
```
h0 = eval(subs(hd));
plot(t, h0, '-k.', 'markersize', 10, 'color', [.8 0 0]);
T = Tf;
S = Sf;
hf = eval(subs(hd));
plot(t, hf, '-k.', 'markersize', 10, 'color', [0 .8 0]);
xlabel('time (hr)');
ylabel('head (m)');
title('Slug Test Results');
legend('Data', ...
       ['Initial Guess:    T=' num2str(T0) ',            S=' num2str(S0)], ...
       ['LMLSQ Results: T=' num2str(Tf) ',   S=' num2str(Sf)]);
```



Part e: Chi^2 contours

```
Ti = [.1:.1:2]';
Si = [3e-4:3e-4:6e-3]';
X2 = [];
idx = [];
for i=1:length(Ti)
    for j = 1:length(Si)
        T = Ti(i);
        S = Si(j);
        r = eval(subs(h));
        xi = r'*r;
        X2 = [X2; xi];
        idx = [idx; i j];
    end
end
X2r = reshape(X2, length(Si), length(Ti))';

figure('units', 'normalized', 'outerposition', [.2 .2 .8 .6]); hold on;
subplot(1,2,1); hold on; box on;
[col,row] = meshgrid(Si,Ti);
[M,c] = contour(col, row, X2r, [1e3 2e3:2e3:12e3], 'ShowText','on', 'color', 'k');
xlabel('Storage coef (S)');
ylabel('Transmissivity (T)');
plot(Sf, Tf, 'r*');
title('Chi-squared contour plot');
Tz1 = .2;     Tz2 = .32;
Sz1 = 1.6e-3; Sz2 = 2.3e-3;
plot([Sz1 Sz1 Sz2 Sz2 Sz1], [Tz1 Tz2 Tz2 Tz1 Tz1], '-b', 'linewidth', 2);

 % make zoom in around minimum
Ti = [Tz1:.005:Tz2]';
Si = [Sz1:.2e-4:Sz2]';
X2 = [];
idx = [];
for i=1:length(Ti)
    for j = 1:length(Si)
        T = Ti(i);
        S = Si(j);
        r = eval(subs(h));
        xi = r'*r;
        X2 = [X2; xi];
        idx = [idx; i j];
    end
end
X2r = reshape(X2, length(Si), length(Ti))';

ax2 = subplot(1,2,2); hold on; box on;
[col,row] = meshgrid(Si,Ti);
```

```
[M,c] = contour(col, row, X2r, [10 50 100 1e2:1e2:6e2], 'ShowText','on', 'color', 'k');
xlabel('Storage coef (S)');
ylabel('Transmissivity (T)');
plot(Sf, Tf, 'r*');
title('Chi-squared contour plot (zoom)');
```



part f: P-value calculation

```
p_value = chi2cdf(chi2,n-length(var0), 'upper')

% This p-value is ~90%, which means that this result is acceptable.
```

```
p_value =

    0.9010
```

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