HW1 Problem 3: Data means, standard deviations

```
fprintf('\n');
clearvars -except function_list hw_pub toolsPath
close all

sets = [0.64 35.0495
0.23 35.0057
0.03 35.4955
0.95 35.2935
0.95 35.3393
0.47 35.4829
0.00 35.6245
0.15 35.4717
0.48 35.7321
0.63 35.4567
0.48 35.0233
0.51 35.7177
0.83 35.8106
0.36 35.3045
0.97 35.6869
0.36 35.0497
0.93 35.1555
0.76 35.7150
0.77 35.9912
0.58 35.3015
0.22 35.5324
0.44 35.9756
0.51 35.2991
0.23 35.2881
0.50 35.4022
0.40 35.8123
0.99 35.7386
0.40 35.5481
0.60 35.6242
0.64 35.6057
0.15 35.3499
0.64 35.6078
0.74 35.9811
0.21 35.3705
0.00 35.3342
0.11 35.0754
0.96 35.9829
0.17 35.3148
0.62 35.2739
0.89 35.7777
0.02 35.9086
0.95 35.2198
0.74 35.6107
0.92 35.7388
```

```
0.61 35.0868
0.58 35.2950
0.45 35.1099
0.10 35.1274
0.18 35.8981
0.27 35.2108
0.61 35.1533
0.20 35.7648
0.59 35.4782
0.86 35.5210
0.54 35.7101
0.67 35.9466
0.57 35.7073
0.38 35.8111
0.38 35.4244
0.43 35.0319
0.76 35.2876
0.95 35.0280
0.39 35.7167
0.38 35.7858
0.05 35.9689
0.62 35.5488
0.20 35.3710
0.23 35.9210
0.72 35.7704
0.73 35.3684
0.04 35.1719
0.19 35.9816
0.97 35.9579
0.73 35.2438
0.06 35.6814
0.76 35.6739
0.27 35.9643
0.07 35.4480
0.59 35.3081
0.62 35.3242
0.52 35.0885
0.16 35.4216
0.91 35.3046
0.45 35.2163
0.01 35.8429
0.25 35.1781
0.22 35.3168
0.32 35.2184
0.30 35.3783
0.08 35.4404
0.66 35.2360
0.53 35.0452
0.94 35.1010
0.12 35.9870
0.87 35.3898
0.98 35.4245
0.45 35.3079
0.29 35.1596
```

```
0.04 35.9471
0.12 35.8883];

means = mean(sets, 1)
standard_devs = std(sets, 0, 1)
set_max = max(sets)
set_min = min(sets)
```

means =

0.4810   35.4877

standard_devs =

0.2953   0.2952

set_max =

0.9900   35.9912

set_min =

0   35.0057

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HW1 Problem 4: Ground station observations

```matlab
fprintf('\n');
clearvars -except function_list hw_pub toolsPath
close all

v = 50; %m/s
h = 100; %m
x0 = 250; %m

x = linspace(-x0, x0, x0*10);

range = sqrt(h*h + x.*x);
range_rate = x./range*v;
zenith = atan2(x,h);

h2 = 50; %m
range2 = sqrt(h2*h2 + x.*x);
range_rate2 = x./range2*v;
zenith2 = atan2(x,h2);

figure('OuterPosition', [0 50 hw_pub.figWidth hw_pub.figHeight])
subplot(3,1,1)
plot(x, range)
hold on
plot(x, range2, 'g')
title('Range')
xlabel('x position (m)')
ylabel('range (m)')
legend('h = 100 m', 'h = 50 m')
subplot(3,1,2)
plot(x, range_rate)
hold on
plot(x, range_rate2, 'g')
title('Range Rate')
xlabel('x position (m)')
ylabel('range rate (m/s)')
legend('h = 100 m', 'h = 50 m')
subplot(3,1,3)
plot(x, zenith*180/pi)
hold on
plot(x, zenith2*180/pi, 'g')
title('Zenith Angle')
xlabel('x position (m)')
ylabel('zenith (deg)')
legend('h = 100 m', 'h = 50 m')

fprintf(['range:\n',...
    '\tthe slope is steep away from the ground station, making the\n',...
    '\tmeasurement more sensitive to changes in x (more accurate)\n.',...
    '\tHowever, it loses accuracy directly above. There are also not\n',...
    '\tunique x/range pairings, so another method must be used to \n',...
```

```
'\tdetermine which side of the transmitter the receiver is on.\n',...
'\tLower values of h make the range measurement more accurate \n',...
'\tcloser to the transmitter\n',...
'range rate:\n',...
'\tThe slope is steep only near the transmitter, so it is not\n',...
'\taccurate at long distances.\n',...
'\tIt has unique x/range rate pairings, so you can tell which side\n',...
'\tof the transmitter the receiver is.\n',...
'\tLower values of h make the range rate measurement less accurate\n',...
'\tuntil the reciever is closest to the transmitter.\n',...
'Zenith angle:\n',...
'\tThe slope is steep only near the transmitter, so it is not\n',...
'\taccurate at long distances.\n',...
'\tIt has unique x/range rate pairings, so you can tell which side\n',...
'\tof the transmitter the receiver is.\n',...
'\tLower values of h make the range rate measurement less accurate\n',...
'\tuntil the reciever is closest to the transmitter.\n'])
```

```
    range:
     the slope is steep away from the ground station, making the
     measurement more sensitive to changes in x (more accurate)
    . However, it loses accuracy directly above. There are also not
     unique x/range pairings, so another method must be used to
     determine which side of the transmitter the receiver is on.
     Lower values of h make the range measurement more accurate
     closer to the transmitter
    range rate:
     The slope is steep only near the transmitter, so it is not
     accurate at long distances.
     It has unique x/range rate pairings, so you can tell which side
     of the transmitter the receiver is.
     Lower values of h make the range rate measurement less accurate
     until the reciever is closest to the transmitter.
    Zenith angle:
     The slope is steep only near the transmitter, so it is not
     accurate at long distances.
     It has unique x/range rate pairings, so you can tell which side
     of the transmitter the receiver is.
     Lower values of h make the range rate measurement less accurate
     until the reciever is closest to the transmitter.
```
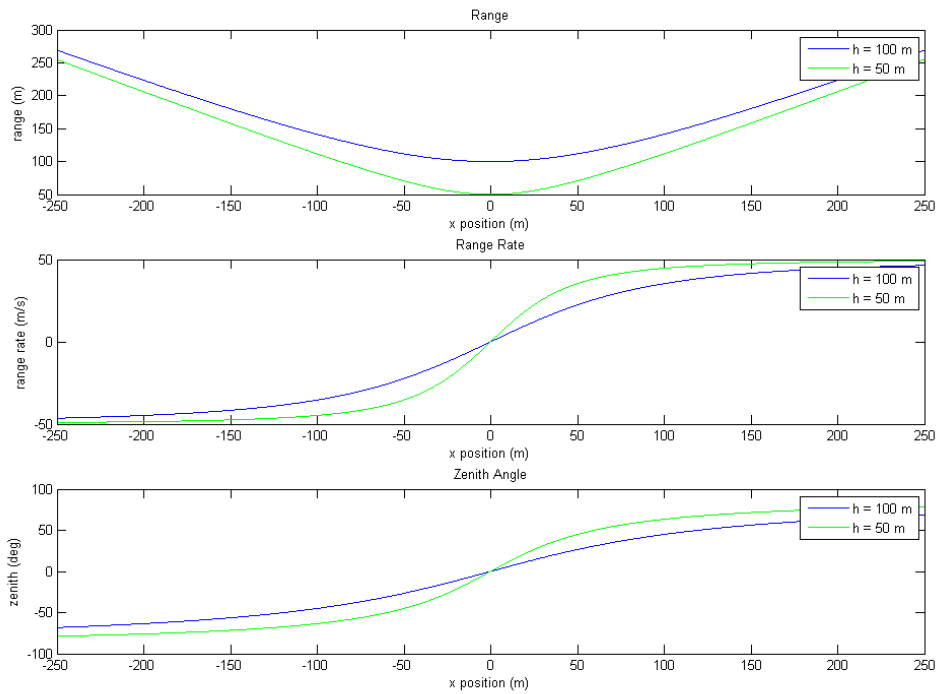
Hyperbolic multilateration

```matlab
figure
hold on
color_opts = ['b';'g'; 'r'];
counter = 1;
for ground_station_spacing = [50 100];
    x1 = -ground_station_spacing/2; %m
    x2 = ground_station_spacing/2; %m
    r1 = sqrt((x1-x).*(x1-x) + h*h);
    r2 = sqrt((x2-x).*(x2-x) + h*h);
    d21 = r2 - r1;
    d21_dot = -(x2-x)./r2*v - -(x1-x)./r1*v;
    subplot(2,1,1)
    hold on
    plot(x, d21, color_opts(counter))
    title('Range Difference')
    xlabel('x position (m)')
    ylabel('\Deltarange (m)')
    legend('50 m tx distance', '100 m tx distance')
    subplot(2,1,2)
    hold on
    plot(x, d21_dot, color_opts(counter))
    title('Range Difference Rate')
    xlabel('x position (m)')
    ylabel('\Deltarange rate (m/s)')
    legend('50 m tx distance', '100 m tx distance')
    counter = counter + 1;
```

```matlab
end
fprintf(['delta range:\n',...
    '\tthe slope is steep closer to the ground station, making the\n',...
    '\tmeasurement more sensitive to changes in x when it approaches \n',...
    '\tthe first transmitter.\n',...
    '\tThere are also unique x/delta-range pairings, so it is known\n',...
    '\twhere the receiver is wrt the transmitters\n',...
    '\tLarger transmitter distances result in more accuracy both between\n',...
    '\tand slightly beyond the transmitters\n',...
    'delta range rate:\n',...
    '\tThe slope is steep just as it approaches the transmitters.\n',...
    '\tIt does not have unique x/delta range rate pairings, so you cannot\n',...
    '\ttell which side of the midpoint the receiver is located.\n',...
    'Delta Range measurement seems most sufficient in this case\n'])
```

Warning: Ignoring extra legend entries.
Warning: Ignoring extra legend entries.
delta range:
 the slope is steep closer to the ground station, making the
 measurement more sensitive to changes in x when it approaches
 the first transmitter.
 There are also unique x/delta-range pairings, so it is known
 *where the receiver is wrt the transmitters*
 Larger transmitter distances result in more accuracy both between
 and slightly beyond the transmitters
delta range rate:
 The slope is steep just as it approaches the transmitters.
 It does not have unique x/delta range rate pairings, so you cannot
 tell which side of the midpoint the receiver is located.
Delta Range measurement seems most sufficient in this case

Range Difference / Range Difference Rate
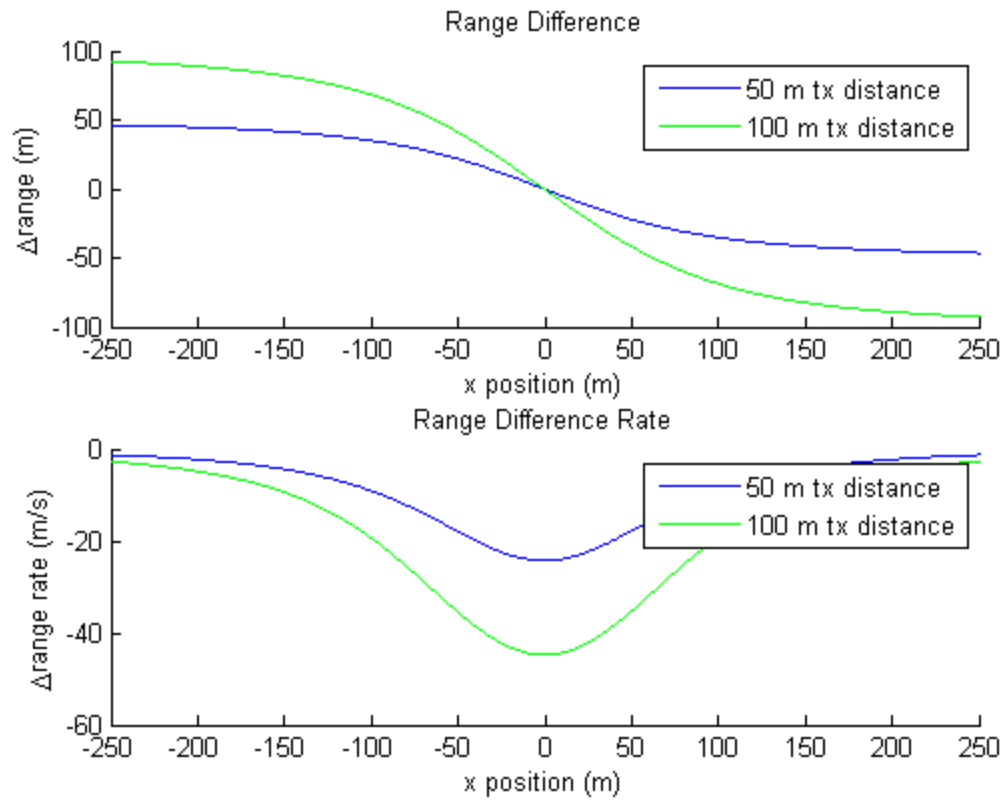
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```matlab
function fcnPrintQueue( filename )
global function_list;
if exist('function_list', 'var')
    file_in_list = 0;
    for idx = 1:length(function_list)
        if strcmp(function_list(idx), filename);
            file_in_list = 1;
            break
        end
    end
    if ~file_in_list
        function_list = [function_list, filename];
    end
end
end
```

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