```matlab
%--------------------------------------------------------------------------
%
%           ADJUSTMENT THEORY I
%  Exercise 11: Adjustment Calculation - part VI
%
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%   Version         : October 12, 2018
%   Last changes    : January 25, 2023
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%--------------------------------------------------------------------------
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%--------------------------------------------------------------------------

clc;
clearvars;
close all;
format longG;

%--------------------------------------------------------------------------
%   Task 1
%--------------------------------------------------------------------------
%--------------------------------------------------------------------------
%   Observations and initial values for the unknowns
%--------------------------------------------------------------------------
%Coordinates - error free values
XG = [4316.175 4036.242 2136.262 1324.177]'; %[m]
YG = [935.411 2055.452 2331.535 1189.218]';    %[m]

%Vector of observations
L = [3491.901 2706.417 922.862 1819.298]';   %[m]

%Number of observations
no_n = length(L);

%Initial values for the unknowns
xP = 3000;
yP = 1500;

%Vector of initial values for the unknowns
X_0 = [xP yP]';

%Number of unknowns
no_u = length(X_0);
```

```
%Redundancy
r = no_n-no_u;

%--------------------------------------------------------------------------
%  Stochastic model
%--------------------------------------------------------------------------


%VC Matrix of the observations
s_L = 0.002+2*L*1e-6; %[m]
S_LL = diag(s_L.^2);

%Theoretical standard deviation
sigma_0 = 1;     %a priori

%Cofactor matrix of the observations
Q_LL = 1/sigma_0^2*S_LL;

%Weight matrix
P = inv(Q_LL);

%--------------------------------------------------------------------------
%  Adjustment
%--------------------------------------------------------------------------
%break-off conditions
epsilon = 1e-5;
delta = 1e-12;
max_x_hat = Inf;
Check2 = Inf;

%Number of iterations
iteration = 0;

while (max_x_hat>epsilon) || (Check2 > delta)

     %Observations as functions of the approximations for the unknowns
     L_0 = sqrt((XG - xP).^2 + (YG - yP).^2);

     %Vector of reduced observations
     l = L-L_0;

     %Design matrix with the elements from the Jacobian matrix J
     A = [-(XG-xP)./L_0 -(YG-yP)./L_0];

     %Normal matrix
     N = A' * P * A;

     %Vector of right hand side of normal equations
     n = A' * P * l;
```

```
    %Inversion of normal matrix / Cofactor matrix of the unknowns
    Q_xx = inv(N);

    %Solution of the normal equations
    x_hat = Q_xx * n;

    %Update
    X_hat = X_0 + x_hat;
    X_0 = X_hat;

    xP = X_hat(1);
    yP = X_hat(2);

    %Check 1
    max_x_hat = max(abs(x_hat));

    %Vector of residuals
    v = A * x_hat - l;

    %Vector of adjusted observations
    L_hat = L + v;

    %Objective function
    vTPv = v' * P * v;

    %Functional relationships without the observations
    phi_X_hat = sqrt((XG - xP).^2 + (YG - yP).^2);

    %Check 2
    Check2 = max(abs(L_hat - phi_X_hat));

    %Update number of iterations
    iteration = iteration+1;

end

if Check2<=delta
    disp('Everything is fine!')
else
    disp('Something is wrong.')
end
```

```
Everything is fine!
```

```
%Empirical reference standard deviation
s_0 = sqrt(vTPv/r);

%VC matrix of adjusted unknowns
S_XX_hat = s_0^2 * Q_xx;
```

```
%Standard deviation of the adjusted unknowns
s_X = sqrt(diag(S_XX_hat));

%Cofactor matrix of adjusted observations
Q_LL_hat = A * Q_xx * A';

%VC matrix of adjusted observations
S_LL_hat = s_0^2 * Q_LL_hat;

%Standard deviation of the adjusted observations
s_L_hat = sqrt(diag(S_LL_hat));

%Cofactor matrix of the residuals
Q_vv = Q_LL - Q_LL_hat;

%VC matrix of residuals
S_vv = s_0^2 * Q_vv;

%Standard deviation of the residuals
s_v = sqrt(diag(S_vv));

% Results
table(X_hat, s_X, 'RowNames', {'xP' 'yP'})
```

ans = 2×2 table

	X_hat	s_X
1 xP	1500.00019447308	0.000311619838406921
2 yP	2999.9999527449	0.000273745240201374

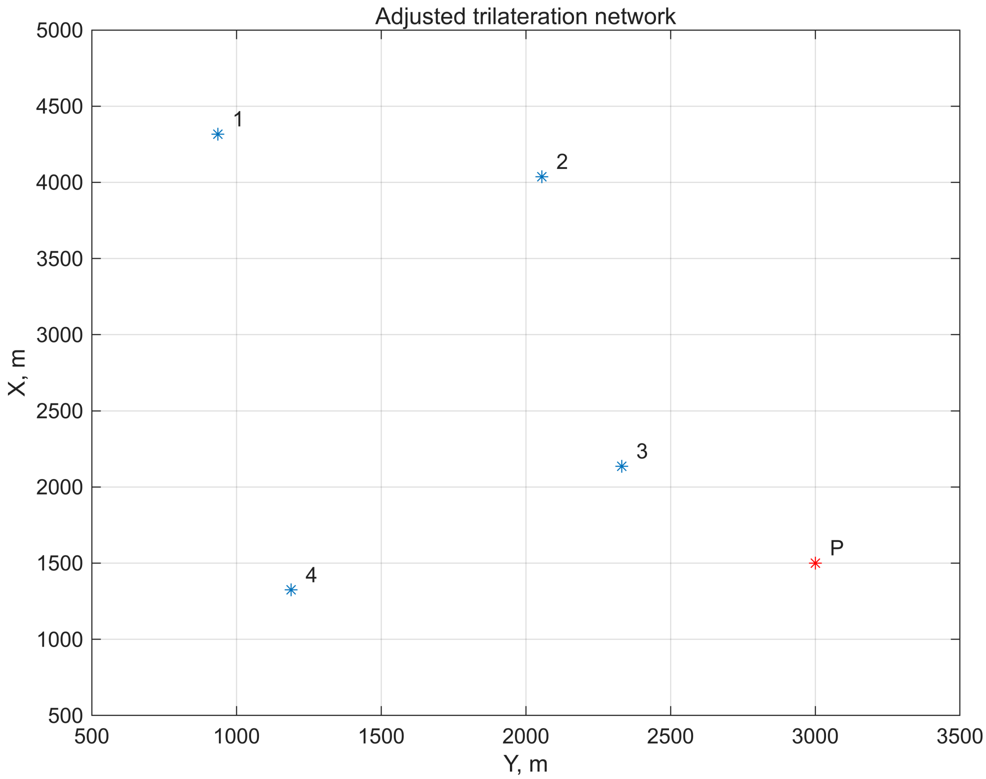
```
table(L, v, L_hat, s_v, s_L_hat)
```

ans = 4×5 table

	L	v	L_hat	s_v	s_L_hat
1	3491.901	-0.000646455977821506	3491.90035354402	0.000461305403749173	0.000188274864100421
2	2706.417	6.52611982793232e-05	2706.4170652612	0.000334049723472426	0.000239646831035274
3	922.862	0.000112246794631069	922.862112246795	0.000128356169441326	0.000170339883686419
4	1819.298	-3.7570168683337e-05	1819.29796242983	0.000108513783114958	0.000293289101181838

```
name = (["1" "2" "3" "4"]);
figure
plot(YG, XG,'*')
grid
xlim([500 3500])
ylim([500 5000])
```

```
xlabel('Y, m')
ylabel('X, m')
text(YG+50, XG+100, name)
title("Adjusted trilateration network")
hold on
plot(yP, xP, '*', Color='red')
text(yP+50, xP+100, "P")
hold off
```



The adjusted position of point P is different from the given on the sketch.