HW3 Solution CE597 (029) Adj. Geospa. Obs.

See solution of problem #3 from homework 2 —

$$W = \begin{bmatrix} 7.11 & & & & 0 \\ & 7.11 & & & \\ & & 64 & & \\ 0 & & & 1 & \\ & & & & 1 \end{bmatrix} \quad \sigma_0 = 0.08 \quad \sigma_0^2 = 0.0064 \quad r = 3$$

$$v = \begin{bmatrix} .0623 \\ -.0489 \\ .0081 \\ -.1280 \\ .0881 \end{bmatrix} \quad \sigma = \begin{bmatrix} .03 \\ .03 \\ .01 \\ .08 \\ .08 \end{bmatrix}$$

test statistic for global test

$$\chi^* = \frac{v^T W v}{\sigma_0^2} = 11.404$$

v's are large compared to σ's

σ's determine where corrections go

small σ, large w } = small correction

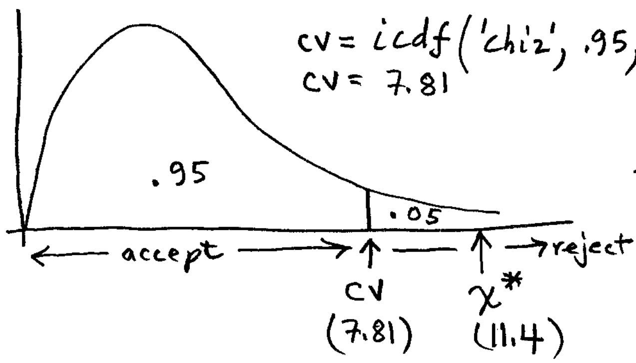
large σ, small w } = large correction

<u>one sided test</u> $H_0: \sigma^2 = \sigma_0^2$

$H_1: \sigma^2 > \sigma_0^2$

@ $\alpha = .05$ level of significance

cv = icdf('chi2', .95, 3)
cv = 7.81

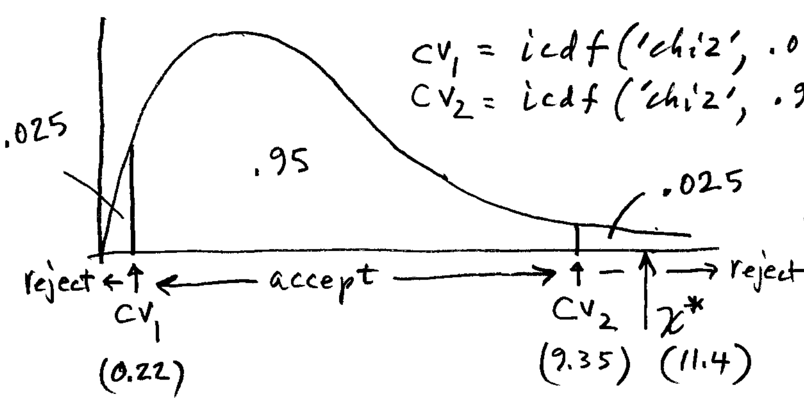


⇒ <u>$\chi^* >$ cv</u> so we reject H_0 and accept H_1

<u>two sided test</u> $H_0: \sigma^2 = \sigma_0^2$ @ $\alpha = .05$ level of significance

$H_1: \sigma^2 \neq \sigma_0^2$

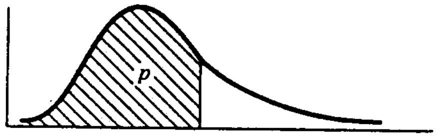
cv_1 = icdf('chi2', .025, 3) = 0.22
cv_2 = icdf('chi2', .975, 3) = 9.35



⇒ <u>$\chi^* > cv_2$</u> so we reject H_0 and accept H_1

See following pages for obtaining critical values via table lookup.

Table II. Percentiles of the Chi-Square Distribution



χ^2_p

DEGREES OF FREEDOM	$\chi^2_{.005}$	$\chi^2_{.01}$	$\chi^2_{.025}$	$\chi^2_{.05}$	$\chi^2_{.10}$	$\chi^2_{.20}$	$\chi^2_{.30}$
1	.000	.000	.001	.004	.016	.064	.148
2	.010	.020	.051	.103	.211	.446	.713
3	.072	.115	.216	.352	.584	1.00	1.42
4	.207	.297	.484	.711	1.06	1.65	2.20
5	.412	.554	.831	1.15	1.61	2.34	3.00
6	.676	.872	1.24	1.64	2.20	3.07	3.83
7	.989	1.24	1.69	2.17	2.83	3.82	4.67
8	1.34	1.65	2.18	2.73	3.49	4.59	5.53
9	1.73	2.09	2.70	3.33	4.17	5.38	6.39
10	2.16	2.56	3.25	3.94	4.87	6.18	7.27
11	2.60	3.05	3.82	4.57	5.58	6.99	8.15
12	3.07	3.57	4.40	5.23	6.30	7.81	9.03
13	3.57	4.11	5.01	5.89	7.04	8.63	9.93
14	4.07	4.66	5.63	6.57	7.79	9.47	10.8
15	4.60	5.23	6.26	7.26	8.55	10.3	11.7
16	5.14	5.81	6.91	7.96	9.31	11.2	12.6
17	5.70	6.41	7.56	8.67	10.1	12.0	13.5
18	6.26	7.01	8.23	9.39	10.9	12.9	14.4
19	6.83	7.63	8.91	10.1	11.7	13.7	15.4
20	7.43	8.26	9.59	10.9	12.4	14.6	16.3
21	8.03	8.90	10.3	11.6	13.2	15.4	17.2
22	8.64	9.54	11.0	12.3	14.0	16.3	18.1
23	9.26	10.2	11.7	13.1	14.8	17.2	19.0
24	9.89	10.9	12.4	13.8	15.7	18.1	19.9
25	10.5	11.5	13.1	14.6	16.5	18.9	20.9
26	11.2	12.2	13.8	15.4	17.3	19.8	21.8
27	11.8	12.9	14.6	16.2	18.1	20.7	22.7
28	12.5	13.6	15.3	16.9	18.9	21.6	23.6
29	13.1	14.3	16.0	17.7	19.8	22.5	24.6
30	13.8	15.0	16.8	18.5	20.6	23.4	25.5
40	20.7	22.1	24.4	26.5	29.0	32.3	34.9
50	28.0	29.7	32.3	34.8	37.7	41.4	44.3
60	35.5	37.5	40.5	43.2	46.5	50.6	53.8

.975 CV

.95 CV_2

← r = 3

$\chi^2_{.50}$	$\chi^2_{.70}$	$\chi^2_{.80}$	$\chi^2_{.90}$	$\chi^2_{.95}$	$\chi^2_{.975}$	$\chi^2_{.99}$	$\chi^2_{.995}$
.455	1.07	1.64	2.71	3.84	5.02	6.63	7.88
1.39	2.41	3.22	4.61	5.99	7.38	9.21	10.6
2.37	3.66	4.64	6.25	7.81	9.35	11.3	12.8
3.36	4.88	5.99	7.78	9.49	11.1	13.3	14.9
4.35	6.06	7.29	9.24	11.1	12.8	15.1	16.7
5.35	7.23	8.56	10.6	12.6	14.4	16.8	18.5
6.35	8.38	9.80	12.0	14.1	16.0	18.5	20.3
7.34	9.52	11.0	13.4	15.5	17.5	20.1	22.0
8.34	10.7	12.2	14.7	16.9	19.0	21.7	23.6
9.34	11.8	13.4	16.0	18.3	20.5	23.2	25.2
10.3	12.9	14.6	17.3	19.7	21.9	24.7	26.8
11.3	14.0	15.8	18.5	21.0	23.3	26.2	28.3
12.3	15.1	17.0	19.8	22.4	24.7	27.7	29.8
13.3	16.2	18.2	21.1	23.7	26.1	29.1	31.3
14.3	17.3	19.3	22.3	25.0	27.5	30.6	32.8
15.3	18.4	20.5	23.5	26.3	28.8	32.0	34.3
16.3	19.5	21.6	24.8	27.6	30.2	33.4	35.7
17.3	20.6	22.8	26.0	28.9	31.5	34.8	37.2
18.3	21.7	23.9	27.2	30.1	32.9	36.2	38.6
19.3	22.8	25.0	28.4	31.4	34.2	37.6	40.0
20.3	23.9	26.2	29.6	32.7	35.5	38.9	41.4
21.3	24.9	27.3	30.8	33.9	36.8	40.3	42.8
22.3	26.0	28.4	32.0	35.2	38.1	41.6	44.2
23.3	27.1	29.6	33.2	36.4	39.4	43.0	45.6
24.3	28.2	30.7	34.4	37.7	40.6	44.3	46.9
25.3	29.2	31.8	35.6	38.9	41.9	45.6	48.3
26.3	30.3	32.9	36.7	40.1	43.2	47.0	49.6
27.3	31.4	34.0	37.9	41.3	44.5	48.3	51.0
28.3	32.5	35.1	39.1	42.6	45.7	49.6	52.3
29.3	33.5	36.2	40.3	43.8	47.0	50.9	53.7
39.3	44.2	47.3	51.8	55.8	59.3	63.7	66.8
49.3	54.7	58.2	63.2	67.5	71.4	76.2	79.5
59.3	65.2	69.0	74.4	79.1	83.3	88.4	92.0

99% confidence interval for X:

$$Q_{\Delta\Delta} = N^{-1} = (B^T W B)^{-1} = \begin{bmatrix} .0917 & .0141 \\ .0141 & .0170 \end{bmatrix}$$

assume pass

$$\Sigma_{\Delta\Delta} = \sigma_0^2 Q_{\Delta\Delta}$$

↖ a priori value, $\sigma_0^2 = .0064$ ← - - - compare!

$$\Sigma_{\Delta\Delta} = \begin{bmatrix} .000587 & .000090 \\ .000090 & .000109 \end{bmatrix}$$

$$\sigma_x = \sqrt{.000587} = .024$$

$$P = 0.99 = 2F(z) - 1, \quad F(z) = \frac{P+1}{2} = .995$$

z = icdf('norm', .995, 0, 1)

$z = 2.58$

interval: $\hat{X} \pm z \cdot \sigma_x$

$$409.97 \pm 2.576 \cdot 0.024$$
$$\pm .062$$

$$409.91 \longrightarrow 410.03$$

assume fail

$$\hat{\sigma}_0^2 = \frac{v^T W v}{r} = .0243$$

← compare!

$$\Sigma_{\Delta\Delta} = \hat{\sigma}_0^2 Q_{\Delta\Delta} = \begin{bmatrix} .002230 & .000344 \\ .000344 & .000412 \end{bmatrix}$$

$$\sigma_x = \sqrt{.002230} = .047$$

$$P = 0.99 = 2F(t) - 1, \quad F(t) = \frac{P+1}{2} = .995$$

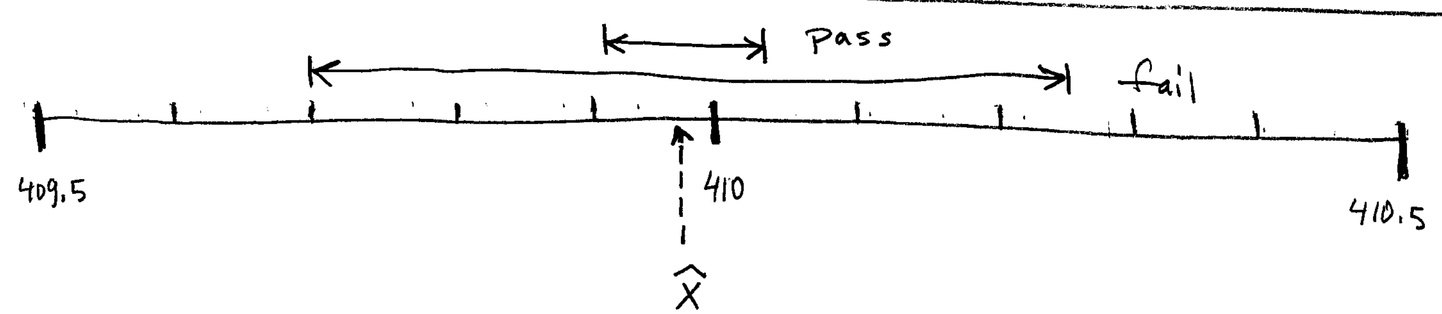
t = icdf('t', .995, 3)

$t = 5.84$

interval: $\hat{X} \pm t \cdot \sigma_x$

$$409.97 \pm 5.841 \cdot .0472$$
$$\pm .276$$

$$409.70 \longrightarrow 410.25$$



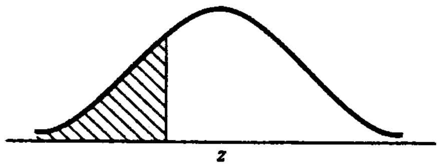
benefit of "good" adjustment = interval is smaller

(stronger statement about position)

see following pages for table lookup for z, t

Table I. Values of the Standard Normal Distribution Function

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-u^2/2}\,du = P\,[Z \leqslant z]$$

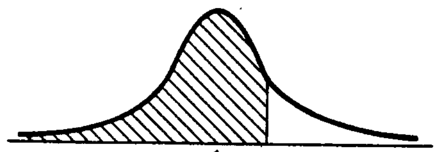


z	0	1	2	3	4	5	6	7	8	9
−3.	.0013	.0010	.0007	.0005	.0003	.0002	.0002	.0001	.0001	.0000
−2.9	.0019	.0018	.0017	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0126	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0238	.0233
−1.8	.0359	.0352	.0344	.0336	.0329	.0322	.0314	.0307	.0300	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0570	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0722	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
− .9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
− .8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
− .7	.2420	.2389	.2358	.2327	.2297	.2266	.2236	.2206	.2177	.2148
− .6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
− .5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
− .4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
− .3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
− .2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
− .1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
− .0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

z	0	1	2	3	4	5	6	7	8	9
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7703	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9278	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9430	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9648	.9656	.9664	.9671	.9678	.9686	.9693	.9700	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9762	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9874	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.	.9987	.9990	.9993	.9995	.9997	.9998	.9998	.9999	.9999	1.0000

$z = 2.575$

Table III. Percentiles of the *t* Distribution



t_p

DEGREES OF FREEDOM	$t_{.55}$	$t_{.60}$	$t_{.65}$	$t_{.70}$	$t_{.75}$	$t_{.80}$	$t_{.85}$
1	.158	.325	.510	.727	1.00	1.38	1.96
2	.142	.289	.445	.617	.816	1.06	1.39
3	.137	.277	.424	.584	.765	.978	1.25
4	.134	.271	.414	.569	.741	.941	1.19
5	.132	.267	.408	.559	.727	.920	1.16
6	.131	.265	.404	.553	.718	.906	1.13
7	.130	.263	.402	.549	.711	.896	1.12
8	.130	.262	.399	.546	.706	.889	1.11
9	.129	.261	.398	.543	.703	.883	1.10
10	.129	.260	.397	.542	.700	.879	1.09
11	.129	.260	.396	.540	.697	.876	1.09
12	.128	.259	.395	.539	.695	.873	1.08
13	.128	.259	.394	.538	.694	.870	1.08
14	.128	.258	.393	.537	.692	.868	1.08
15	.128	.258	.393	.536	.691	.866	1.07
16	.128	.258	.392	.535	.690	.865	1.07
17	.128	.257	.392	.534	.689	.863	1.07
18	.127	.257	.392	.534	.688	.862	1.07
19	.127	.257	.391	.533	.688	.861	1.07
20	.127	.257	.391	.533	.687	.860	1.06
21	.127	.257	.391	.532	.686	.859	1.06
22	.127	.256	.390	.532	.686	.858	1.06
23	.127	.256	.390	.532	.685	.858	1.06
24	.127	.256	.390	.531	.685	.857	1.06
25	.127	.256	.390	.531	.684	.856	1.06
26	.127	.256	.390	.531	.684	.856	1.06
27	.127	.256	.389	.531	.684	.855	1.06
28	.127	.256	.389	.530	.683	.855	1.06
29	.127	.256	.389	.530	.683	.854	1.05
30	.127	.256	.389	.530	.683	.854	1.05
∞	.126	.253	.385	.524	.674	.842	1.04

.995

t = 5.84

$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.9995}$
3.08	6.31	12.7	31.8	63.7	637
1.89	2.92	4.30	6.96	9.92	31.6
1.64	2.35	3.18	4.54	5.84	12.9
1.53	2.13	2.78	3.75	4.60	8.61
1.48	2.01	2.57	3.36	4.03	6.86
1.44	1.94	2.45	3.14	3.71	5.96
1.42	1.90	2.36	3.00	3.50	5.40
1.40	1.86	2.31	2.90	3.36	5.04
1.38	1.83	2.26	2.82	3.25	4.78
1.37	1.81	2.23	2.76	3.17	4.59
1.36	1.80	2.20	2.72	3.11	4.44
1.36	1.78	2.18	2.68	3.06	4.32
1.35	1.77	2.16	2.65	3.01	4.22
1.34	1.76	2.14	2.62	2.98	4.14
1.34	1.75	2.13	2.60	2.95	4.07
1.34	1.75	2.12	2.58	2.92	4.02
1.33	1.74	2.11	2.57	2.90	3.96
1.33	1.73	2.10	2.55	2.88	3.92
1.33	1.73	2.09	2.54	2.86	3.88
1.32	1.72	2.09	2.53	2.84	3.85
1.32	1.72	2.08	2.52	2.83	3.82
1.32	1.72	2.07	2.51	2.82	3.79
1.32	1.71	2.07	2.50	2.81	3.77
1.32	1.71	2.06	2.49	2.80	3.74
1.32	1.71	2.06	2.48	2.79	3.72
1.32	1.71	2.06	2.48	2.78	3.71
1.31	1.70	2.05	2.47	2.77	3.69
1.31	1.70	2.05	2.47	2.76	3.67
1.31	1.70	2.04	2.46	2.76	3.66
1.31	1.70	2.04	2.46	2.75	3.65
1.28	1.64	1.96	2.33	2.58	3.29

r = 3

```
dist5ep
B =
      0.42589       0.90477
      0.99905    -0.043544
      0.19971     -0.97986
     -0.94523      -0.3264
     -0.77559      0.63124
f =
      -2.4229
      -0.4799
       2.3474
       1.1803
      -1.0864
W =
       7.1111             0             0             0             0
            0        7.1111             0             0             0
            0             0            64             0             0
            0             0             0             1             0
            0             0             0             0             1
iter =
     1
del =
     -0.53606
      -2.4965
iter =
     2
del =
    0.0069202
  -0.00071653
iter =
     3
del =
 -1.8437e-006
 -3.7711e-007
iter =
     4
del =
  5.0073e-010
  7.4537e-011
ans =
       409.97         459.9
v =
     0.062305
     -0.04888
    0.0081451
     -0.12798
     0.088116
dhat =
       353.51
        285.2
       270.56
       343.05
       298.37
test =
       11.404
r =
     3
cv =
       7.8147
one sided test fails
cv1 =
       0.2158
cv2 =
```

```
       9.3484
two sided test fails
assume pass
Qdd =
     0.091656     0.014143
     0.014143     0.016953
SIGMA (pass)
S =
    0.0005866  9.0517e-005
  9.0517e-005    0.0001085
x0 =
       409.97
half interval
z =
       2.5758
sx =
      0.02422
hf =
     0.062386
interval bounds
ans =
       409.91
ans =
       410.03
assume fail
ref_var_hat =
     0.024328
ref_std_dev_hat =
      0.15598
SIGMA (fail)
S =
    0.0022298   0.00034408
   0.00034408   0.00041245
x0 =
       409.97
half interval
tt =
       5.8409
sx =
     0.047221
hf =
      0.27582
interval bounds
ans =
        409.7
ans =
       410.25
diary off
```

```
% dist5ep.m  20-oct-08
% 5 range 2D resection problem with error propagation
% (post addjustment statistics)
% initial approx (see graphics for approx)
x0=410.5;
y0=462.4;
n=5;
n0=2;
r=n-n0;
c=n;
u=n0;
B=zeros(c,u);
f=zeros(c,1);
sig0=0.08;
sig=[0.03;0.03;0.01;0.08;0.08];
w=zeros(n,1);
for i=1:n
  w(i)=sig0^2/sig(i)^2;
  end
W=diag(w);
X=[560;695;465;85;180];
Y=[780;450;195;350;650];
d=[353.45;285.25;270.55;343.18;298.28];
keep_going=1;
iter=1;
while (keep_going == 1)
  for i=1:n
    D=sqrt((x0-X(i))^2 + (y0-Y(i))^2);
    B(i,1)=-(x0-X(i))/D;
    B(i,2)=-(y0-Y(i))/D;
    Fi=d(i)-D;
    f(i)=-Fi;
    end
  N=B'*W*B;
  t=B'*W*f;
  if(iter==1)
    B
    f
    W
    end;
  iter
  del=inv(B'*W*B)*B'*W*f
  if (all(abs(del)<1.0e-06) | (iter > 10))
    keep_going=0;
    end
  x0=x0 + del(1);
  y0=y0 + del(2);
  iter=iter+1;
  end

[x0 y0]
v=f-B*del
```

```
dhat=d + v

% make one sided global test

alpha=0.05;
test=v'*W*v/(sig0^2);
cv=icdf('chi2',1-alpha,r);
test
r
cv
if(test < cv)
  disp('one sided test passes');
else
  disp('one sided test fails');
  end

% make two-sided test

cv1=icdf('chi2',alpha/2,r);
cv2=icdf('chi2',1-alpha/2,r);
cv1
cv2
if((test > cv1) & (test < cv2))
  disp('two sided test passes');
else
  disp('two sided test fails');
  end

% assume pass for 99% confidence interval

disp('assume pass');
Qdd=inv(N);
Qdd
disp('SIGMA (pass)');
S=sig0^2 * Qdd
sx=sqrt(S(1,1));
% P = 2*F(z) - 1
% F(z) = (P+1)/2
z=icdf('norm',0.995,0,1);
% X-hat +/- z*sigx

x0

disp('half interval')
z
sx
hf=z*sx
disp('interval bounds');
x0-hf
x0+hf

% assume fail for 99% confidence interval
```

```
disp('assume fail');
ref_var_hat=v'*W*v/r
ref_std_dev_hat=sqrt(ref_var_hat)
Qdd=inv(N);
disp('SIGMA (fail)');
S=ref_var_hat * Qdd
sx=sqrt(S(1,1));
% P = 2*F(t) - 1
% F(t) = (P+1)/2
tt=icdf('t',0.995,r);
% X-hat +/- t*sigx

x0

disp('half interval')
tt
sx
hf=tt*sx
disp('interval bounds');
x0-hf
x0+hf
```