

1. problem 1

(a) Matlab Code

```
% problem 1
result = ones(1,3);
hb = hilb(5);
invhb1 = invhilb(5);
result(1,1) = cond(hb);
condhb = cond(hb);
muti1 = invhb1 * hb;
n1 = norm(muti1 - eye(5));
result(1,2) = norm(muti1 - eye(5));
invhb2 = inv(hb);
muti2 = invhb2 * hb;
n2 = norm(muti2 - eye(5));
result(1,3) = norm(muti2 - eye(5));
```

(b) Result

Table 1: Problem 1 result		
Condition Number	Norm(invhill)	Norm(inv)
476607.2502	3.30E-12	5.42E-12

(c) Analysis

In this result, We can see that we use the invhilb function the norm is a bit smaller then when we use inv function.

2. Problem 2

(a) Matlab Code

```
% problem 2
result = ones(30,4);
for n=1.0:1.0:30.0
```

```

    result(n,1)=n;
    n=single(n); // for problem 3 just delete this line
    disp(n)
    hb = hilb(n);
    result(n,2) = cond(hb);

    invhb1 = invhilb(n);
    result(n,3) = norm(invhb1 * hb - eye(n));

    invhb2 = inv(hb);
    result(n,4) = norm(invhb2 * hb - eye(n));
    result(n,5) = norm(hb * invhb2 - eye(n));
end

```

(b) Result

See Table 2.

(c) Analysis

In this result, we can see that after $N=7$, the result norm when we use `invhilb` function grows much faster. However, when we use `inv` function, the error grow slowly with N , even when we transverse matrix and it's inverse, the grow speed still slower then when we use `invhilb` function.

3. Problem 3

(a) Matlab code

Almost same with problem 2, without transiting n to single precision

(b) Result

See Table 3.

4. Problem 4

(a) Matlab Code

```

% problem 4
result = ones(30,10);
t = ones(1000,3);

for n=1:1:30
    result(n,1)=n;

```

```

imat = eye(n);
for i=1:1:1000
    mat = rand(n);
    t(i,1) = cond(mat);
    invMat = inv(mat);
    t(i,2) = norm(mat * invMat - imat);
    t(i,3) = norm(invMat * mat - imat);
end
result(n,2:3:8)=mean(t);
result(n,3:3:9)=min(t);
result(n,4:3:10)=max(t);
end

```

(b) Result

See Table 4.

Table 2: Problem 2 result

N	Condition Number	Norm(invhilb(n)*hb-I)	Norm(inv(hb)*hb-I)	Norm(hb*inv(hb)-I);
1	1	0	0	0
2	19.28147007	0	0	0
3	524.0567776	5.53E-15	5.16E-15	1.15E-14
4	15513.73874	5.68E-14	2.24E-13	7.73E-13
5	476607.2502	3.30E-12	5.42E-12	1.60E-11
6	14951058.64	2.91E-11	2.96E-10	6.24E-10
7	475367356.9	3.27961587	6.71E-09	3.13E-08
8	15257575567	79.94611195	1.39E-07	3.44E-07
9	4.93153E+11	1251.565225	3.40E-06	7.07E-05
10	1.6025E+13	146613.9995	9.54E-05	0.005255255
11	5.22021E+14	4360783.378	0.005498944	0.32605126
12	1.62E+16	155412217.1	0.147410377	9.668459327
13	4.79E+17	3756392498	11.35469582	3827.582711
14	2.55E+17	1.93573E+11	7.959829528	678.4249045
15	2.50E+17	4.75311E+12	5.558526585	2284.37268
16	4.89E+17	1.73523E+14	2.610041956	5395.664778
17	4.51E+17	3.35E+15	4.610668852	2876.456006
18	1.35E+18	1.26E+17	5.327320428	17831.50172
19	1.26E+18	2.93E+18	5.954997701	26840.33873
20	2.11E+18	6.37E+19	20.05690775	202354.1836
21	2.73E+18	6.75E+21	17.54948243	476625.5474
22	2.18E+18	1.55E+23	43.4508265	1474294.739
23	1.54E+18	5.75E+24	15.34482603	2356620.246
24	6.67E+18	8.98E+25	56.17224908	6871438.673
25	1.89E+19	NaN	12.49822993	535508.8268
26	1.59E+18	NaN	15.65737976	7666886.124
27	2.49E+18	NaN	32.81955573	1360561.489
28	6.75E+18	NaN	228.7018358	96520675.71
29	6.25E+19	NaN	55.79752247	4652130.477
30	5.10E+18	NaN	15.20744641	9593405.167

Table 3: Problem 3 result

N	Condition Number	Norm(invhilb(n)*hb-I)	Norm(inv(hb)*hb-I)	Norm(hb*inv(hb)-I);
1	1	0	0	0
2	19.28147007	0	0	0
3	524.0567776	5.53E-15	5.16E-15	1.15E-14
4	15513.73874	5.68E-14	2.24E-13	7.73E-13
5	476607.2502	3.30E-12	5.42E-12	1.60E-11
6	14951058.64	2.91E-11	2.96E-10	6.24E-10
7	475367356.9	4.87E-09	6.71E-09	3.13E-08
8	15257575567	1.79E-07	1.39E-07	3.44E-07
9	4.93153E+11	5.19E-06	3.40E-06	7.07E-05
10	1.6025E+13	0.000161297	9.54E-05	0.005255255
11	5.22021E+14	0.004715871	0.005498944	0.32605126
12	1.62E+16	0.125577718	0.147410377	9.668459327
13	4.79E+17	10.56769535	11.35469582	3827.582711
14	2.55E+17	284.7419042	7.959829528	678.4249045
15	2.50E+17	8678.094103	5.558526585	2284.37268
16	4.89E+17	169392.1204	2.610041956	5395.664778
17	4.51E+17	8.61E+06	4.610668852	2876.456006
18	1.35E+18	3.07E+08	5.327320428	17831.50172
19	1.26E+18	6.26E+09	5.954997701	26840.33873
20	2.11E+18	2.21E+11	20.05690775	202354.1836
21	2.73E+18	7.83E+12	17.54948243	476625.5474
22	2.18E+18	2.28E+14	43.4508265	1474294.739
23	1.54E+18	7.19E+15	15.34482603	2356620.246
24	6.67E+18	1.78E+17	56.17224908	6871438.673
25	1.89E+19	1.25E+19	12.49822993	535508.8268
26	1.59E+18	3.30E+20	15.65737976	7666886.124
27	2.49E+18	8.84E+21	32.81955573	1360561.489
28	6.75E+18	2.73E+23	228.7018358	96520675.71
29	6.25E+19	1.11E+25	55.79752247	4652130.477
30	5.10E+18	2.66E+26	15.20744641	9593405.167

Table 4: Problem 4 result

N	MeanConditionNumber	Min.	Max.	MeanNm(M*inv-I)	Min.	Max.	MeanNm(inv*M-I)	Min.	Max.
1	1	1	1	1.73E-17	0	1.11E-16	1.73E-17	0	1.11E-16
2	39.77978269	1.128098963	15045.78253	2.64E-15	0	1.62E-12	1.11E-15	0	4.55E-13
3	208.3828163	2.61E+00	1.55E+05	8.67E-15	2.38E-17	6.30E-12	4.12E-15	5.13E-17	2.41E-12
4	57.85314957	3.41E+00	5.61E+03	2.88E-15	1.98E-16	1.68E-13	2.04E-15	1.69E-16	1.25E-13
5	7000.133272	5.51E+00	5.38E+06	2.46E-13	2.25E-16	2.00E-10	1.95E-13	2.39E-16	1.33E-10
6	278.4251097	6.97E+00	5.02E+04	1.33E-14	2.77E-16	3.27E-12	9.15E-15	3.97E-16	2.18E-12
7	208.7330519	8.63E+00	1.36E+04	1.36E-14	4.61E-16	9.21E-13	6.52E-15	4.46E-16	2.86E-13
8	552.5539039	1.11E+01	2.49E+05	3.24E-14	6.13E-16	1.28E-11	1.56E-14	4.03E-16	6.37E-12
9	414.0638461	1.60E+01	1.20E+05	2.01E-14	8.37E-16	3.83E-12	1.26E-14	6.34E-16	3.23E-12
10	329.740625	15.62337083	2.55E+04	1.97E-14	9.84E-16	1.63E-12	1.04E-14	7.98E-16	9.66E-13
11	350.837356	21.67726661	28069.84375	2.40E-14	1.45E-15	1.29E-12	1.11E-14	8.26E-16	7.26E-13
12	6.91E+02	24.07534521	280235.9236	5.25E-14	1.45E-15	2.57E-11	2.35E-14	1.02E-15	1.01E-11
13	4.68E+02	26.86175716	36039.06419	3.14E-14	2.07E-15	2.36E-12	1.55E-14	1.24E-15	1.24E-12
14	7.42E+02	28.406415	90326.43239	5.24E-14	2.27E-15	8.08E-12	2.31E-14	1.04E-15	2.35E-12
15	5.61E+02	25.69008064	48296.62039	3.83E-14	1.85E-15	4.61E-12	1.86E-14	1.36E-15	2.00E-12
16	1.21E+03	34.32014546	341271.1556	8.94E-14	2.88E-15	2.93E-11	3.88E-14	1.57E-15	9.93E-12
17	7.70E+02	3.44E+01	45928.53243	5.82E-14	2.95E-15	5.39E-12	2.54E-14	1.78E-15	1.86E-12
18	6.06E+02	3.85E+01	34452.2836	4.36E-14	3.28E-15	2.38E-12	1.99E-14	1.63E-15	9.93E-13
19	1.01E+03	4.86E+01	87520.92327	8.07E-14	4.01E-15	8.88E-12	3.31E-14	1.94E-15	2.99E-12
20	2.40E+03	5.01E+01	805597.7878	1.70E-13	4.36E-15	4.73E-11	8.11E-14	2.44E-15	3.05E-11
21	2.68E+03	5.58E+01	1576914.371	1.96E-13	5.17E-15	1.09E-10	1.02E-13	2.22E-15	6.66E-11
22	1.78E+03	6.19E+01	317751.5596	1.23E-13	5.84E-15	1.50E-11	5.63E-14	2.62E-15	1.05E-11
23	1.44E+03	5.24E+01	277883.9107	1.13E-13	5.71E-15	1.60E-11	4.78E-14	2.39E-15	9.10E-12
24	3.06E+03	7.25E+01	488186.7964	2.44E-13	6.06E-15	3.73E-11	9.57E-14	2.86E-15	1.45E-11
25	2.49E+03	5.99E+01	504718.6499	2.26E-13	6.21E-15	5.07E-11	8.62E-14	3.08E-15	1.49E-11
26	1.54E+03	6.25E+01	80026.17056	1.25E-13	6.52E-15	8.18E-12	5.37E-14	3.26E-15	4.34E-12
27	1.53E+03	8.76E+01	121137.8023	1.32E-13	9.03E-15	1.09E-11	5.07E-14	3.48E-15	3.47E-12
28	1.61E+03	8.83E+01	189418.669	1.44E-13	6.78E-15	2.27E-11	5.65E-14	3.26E-15	7.93E-12
29	2.08E+03	8.30E+01	223392.5077	1.82E-13	9.49E-15	1.65E-11	7.13E-14	3.56E-15	8.01E-12
30	1.84E+03	8.83E+01	337279.9273	1.70E-13	9.06E-15	3.22E-11	6.62E-14	3.10E-15	1.41E-11