

```
//          理論請參考說明
//          汎用 3 維邊界元素法(積分方程式) 2011.12.25 周宗仁編輯
```

```
//x,y,z      表示各節點座標
//xn,yn,zn   表示各元素法線方向單位向量
//a          表示各元素面積
//elm        表示各元素內節點編號
//jnb        表示各節點上的相鄰元素數量
//nei        表示各節點上的相鄰元素編號
//nt         表示總節點數
//et         表示總元素數
```

```
class Bem3D{
```

```
public void bem(double [][]h,double [][]g,double []x,double []y,double []z,double
[]xn,double []yn,double []zn,
```

```
double []a,int [][]elm,int []jnb,int [][]nei,int nt,int et){
```

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```
normal(et,x,y,z,elm,xn,yn,zn,a);          // 各元素法線向量分量及
```

面積

```
hg(h,g,x,y,z,xn,yn,zn,a,elm,jnb,nei,nt,et); // H 及 G
```

```
minvs(h,nt,nt,0.00005);          // [H+I]的逆列陣
```

```
seki(h,g,nt,nt,nt,nt);          // [H+I]的逆列陣乘以
```

[G]

```
}//bem
```

```
public void hg(double [][]h,double [][]g,double []x,double []y,double []z,double
[]xn,double []yn,double []zn,
```

```
double []a,int [][]elm,int []jnb,int [][]nei,int nt,int et){
```

```
double [][]p=new double[2][2];
```

```
double [][]e=new double[2][2];
```

```
double [][]xg=new double[et][4];
```

```
double [][]yg=new double[et][4];
```

```
double [][]zg=new double[et][4];
```

```
double [][]gs=new double[nt][8];
```

```
int wl,wm,l,m,lm,n,i,j,k,jj;
```

```
double hh,gg,f1,f2,f3,f4,rx,ry,rz,rsx,rsy,rsz,gs1,gs2,gs3,qr;
```

```
double pc,rilm,rilm2,rn;
```

```
double pi=Math.PI;
```

```
pc=0;n=0;rsx=0;rsy=0;rsz=0;gs1=0;gs2=0;gs3=0;rx=0;ry=0;rz=0;
```

```
wl=1;    wm=1;
```

```
qr=1./Math.sqrt(3.);
```

```
p[1][1]=-qr;
```

```
e[1][1]=-qr;
```

```
p[1][2]= qr;
```

```
e[1][2]=-qr;
```

```
p[2][1]= qr;
```

```
e[2][1]= qr;
```

```
p[2][2]=-qr;
```

```
e[2][2]= qr;
```

```
for(j=1;j<=et;j++){
```

```
    for(l=1;l<=2;l++){
```

```
        for(m=1;m<=2;m++){
```

```
            f1=(1-p[l][m]-e[l][m]+p[l][m]*e[l][m])/4.;
```

```
            f2=(1+p[l][m]-e[l][m]-p[l][m]*e[l][m])/4.;
```

```
            f3=(1+p[l][m]+e[l][m]+p[l][m]*e[l][m])/4.;
```

```
            f4=(1-p[l][m]+e[l][m]-p[l][m]*e[l][m])/4.;
```

```
            lm=m+2*(l-1);
```

```
            xg[j][lm]=f1*x[elm[j]][1]+f2*x[elm[j]][2]+f3*x[elm[j]][3]+f4*x[elm[j]][4];
```

```
            yg[j][lm]=f1*y[elm[j]][1]+f2*y[elm[j]][2]+f3*y[elm[j]][3]+f4*y[elm[j]][4];
```

```
            zg[j][lm]=f1*z[elm[j]][1]+f2*z[elm[j]][2]+f3*z[elm[j]][3]+f4*z[elm[j]][4]; }}
```

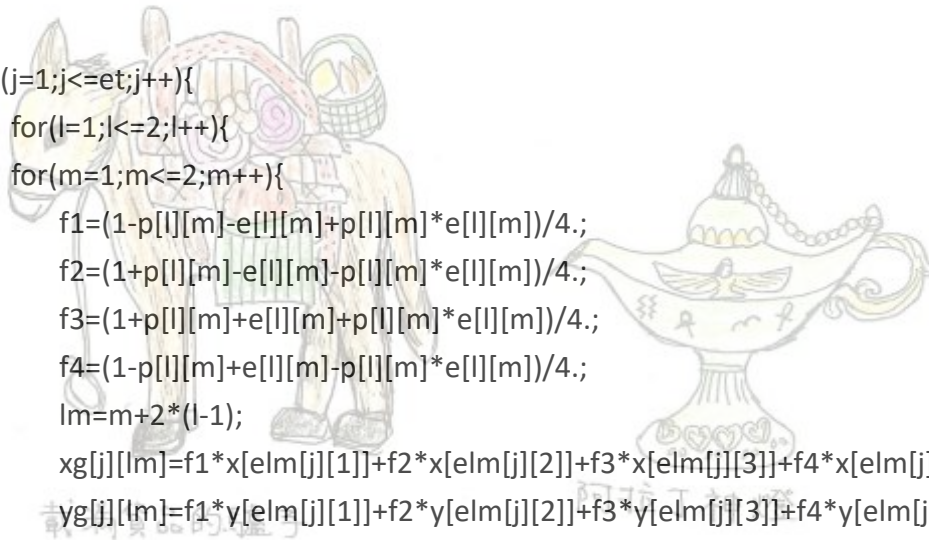
```
    }
```

```
for(j=1;j<=nt;j++){
```



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```
for(k=1;k<=jnb[j];k++){
```

```
    for(m=1;m<=4;m++){if(x[j]==x[elm[nei[j][jnb[k]]][m]] &&
y[j]==y[elm[nei[j][jnb[k]]][m]] ) n=m; }
```

```
    for(m=1;m<=4;m++){
        if(m==1) pc=-1;
        if(m==2) pc= 1;
        if(m==3) pc= 1;
        if(m==4) pc=-1;

rx=.25*((-1+pc)*x[elm[j][1]]-(1+pc)*x[elm[j][2]]+(1+pc)*x[elm[j][3]]+(1-pc)*x[elm[j][4]]);

ry=.25*((-1+pc)*y[elm[j][1]]-(1+pc)*y[elm[j][2]]+(1+pc)*y[elm[j][3]]+(1-pc)*y[elm[j][4]]);
```

```
rz=.25*((-1+pc)*z[elm[j][1]]-(1+pc)*z[elm[j][2]]+(1+pc)*z[elm[j][3]]+(1-pc)*z[elm[j][4]]);}
```

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```
if(n==1 | n==2) {
    rsx=.5*(x[elm[j][3]]-x[elm[j][4]]);
    rsy=.5*(y[elm[j][3]]-y[elm[j][4]]);
    rsz=.5*(z[elm[j][3]]-z[elm[j][4]]); }
```

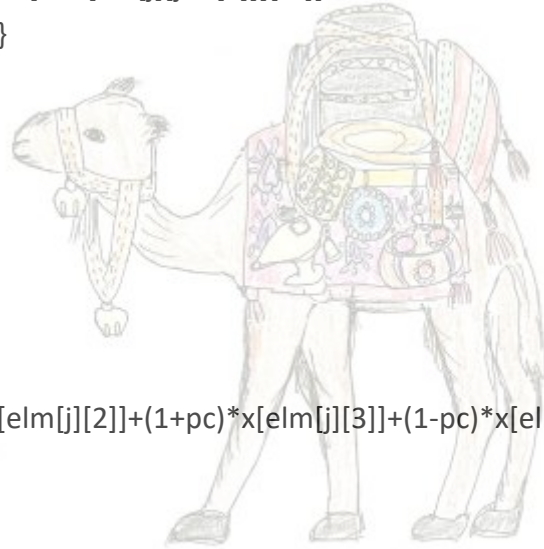
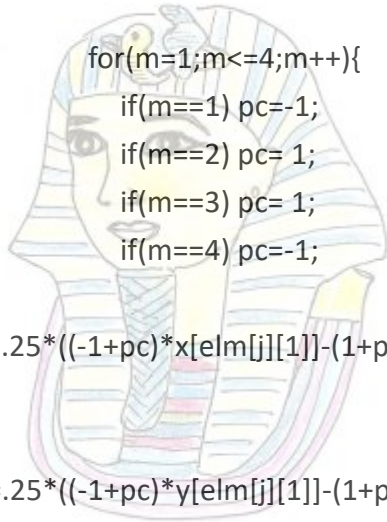
```
if(n==3 | n==4) {
    rsx=.5*(x[elm[j][2]]-x[elm[j][1]]);
    rsy=.5*(y[elm[j][2]]-y[elm[j][1]]);
    rsz=.5*(z[elm[j][2]]-z[elm[j][1]]);}
```

```
gs1=rsy*rz-rsz*ry;
gs2=rsz*rx-rsx*rz;
gs3=rsx*ry-rsy*rx;
```

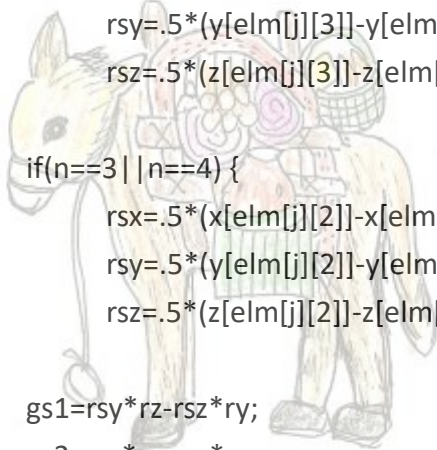
```
gs[j][k]=Math.sqrt(gs1*gs1+gs2*gs2+gs3*gs3);
```

```
}}
```

```
for(i=1;i<=nt;i++){ for(j=1;j<=nt;j++){h[i][j]=0;g[i][j]=0;}}
```



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```
for(i=1;i<=nt;i++){
for(jj=1;jj<=nt;jj++){
```

```
if(i!=jj){
    hh=0;
    gg=0;
    for(k=1;k<=jnb[jj];k++){
        j=nei[jj][jnb[k]];
        for(m=1;m<=4;m++){if(x[jj]==x[elm[j][m]] && y[jj]==y[elm[j][m]]) n=m; }

        for(l=1;l<=2;l++){
            for(m=1;m<=2;m++){
                lm=m+2*(l-1);
```

```
    rilm=(x[i]-xg[j][lm])*(x[i]-xg[j][lm])+(y[i]-yg[j][lm])*(y[i]-yg[j][lm])+(z[i]-zg[j][lm])*(z[i]-
    zg[j][lm]);
```

```
    rilm2=Math.sqrt(rilm);
```

```
    rn=(xg[j][lm]-x[i])*xn[j]+(yg[j][lm]-y[i])*yn[j]+(zg[j][lm]-z[i])*zn[j];
```

```
    rn=rn/rilm2;
```

```
if(n==1){
```

```
    hh=hh+wl*wm*(1-p[l][m]-e[l][m]+p[l][m]*e[l][m])/rilm*rn*a[j];
```

```
    gg=gg+wl*wm*(1-p[l][m]-e[l][m]+p[l][m]*e[l][m])/rilm2*a[j];}
```

```
if(n==2){
```

```
    hh=hh+wl*wm*(1+p[l][m]-e[l][m]-p[l][m]*e[l][m])/rilm*rn*a[j];
```

```
    gg=gg+wl*wm*(1+p[l][m]-e[l][m]-p[l][m]*e[l][m])/rilm2*a[j];}
```

```
if(n==3){
```

```
    hh=hh+wl*wm*(1+p[l][m]+e[l][m]+p[l][m]*e[l][m])/rilm*rn*a[j];
```

```
    gg=gg+wl*wm*(1+p[l][m]+e[l][m]+p[l][m]*e[l][m])/rilm2*a[j];}
```

```
if(n==4){
```

```
    hh=hh+wl*wm*(1-p[l][m]+e[l][m]-p[l][m]*e[l][m])/rilm*rn*a[j];
```

```
    gg=gg+wl*wm*(1-p[l][m]+e[l][m]-p[l][m]*e[l][m])/rilm2*a[j];}
```

```
}}
```

```
h[i][jj]=-1./8/pi*hh;
```

```
g[i][jj]= 1./8/pi*gg; }
```



```

}    //i!=jj

if(i==jj){
    gg=0;
    for(k=1;k<=jnb[jj];k++){
        j=nei[jj][jnb[k]];
        for(m=1;m<=4;m++){if(x[j]==x[elm[j][m]] && y[j]==y[elm[j][m]]) n=m; }

        for(l=1;l<=2;l++){
            for(m=1;m<=2;m++){
                lm=m+2*(l-1);

rilm=(x[i]-xg[j][lm])*(x[i]-xg[j][lm])+(y[i]-yg[j][lm])*(y[i]-yg[j][lm])+(z[i]-zg[j][lm])*(z[i]-
zg[j][lm]);
                rilm2=Math.sqrt(rilm);
                rn=(xg[j][lm]-x[i])*xn[j]+(yg[j][lm]-y[i])*yn[j]+(zg[j][lm]-z[i])*zn[j];
                rn=rn/rilm2;

```

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```

if(n==1){gg=gg+wl*wm*(1-p[l][m]-e[l][m]+p[l][m]*e[l][m])/rilm2*gs[i][k];}

if(n==2){gg=gg+wl*wm*(1+p[l][m]-e[l][m]-p[l][m]*e[l][m])/rilm2*gs[i][k];}

if(n==3){gg=gg+wl*wm*(1+p[l][m]+e[l][m]+p[l][m]*e[l][m])/rilm2*gs[i][k];}

if(n==4){gg=gg+wl*wm*(1-p[l][m]+e[l][m]-p[l][m]*e[l][m])/rilm2*gs[i][k];}
    }}
    g[i][jj]= 1./8/pi*gg; }

}    //i=jj

if(i==jj) h[i][jj]=h[i][jj]+1;
}}
} //hg

```

```

public void normal(int nelm,double []px,double []py,double []pz,int [][]mtj,double
[]xn,double []yn,double []zn,double []area){

```

```
double r,r1,r2,r3,r4,r5,r6,t,t1,t2,t3,t4,t5,t6;
```

```
int i;
```

```
for(i=1;i<=nelm;i++){
```

```
    r1=px[mtj[i][3]]-px[mtj[i][1]];
```

```
    r2=py[mtj[i][3]]-py[mtj[i][1]];
```

```
    r3=pz[mtj[i][3]]-pz[mtj[i][1]];
```

```
    r4=px[mtj[i][4]]-px[mtj[i][2]];
```

```
    r5=py[mtj[i][4]]-py[mtj[i][2]];
```

```
    r6=pz[mtj[i][4]]-pz[mtj[i][2]];
```

```
r=Math.sqrt((r5*r3-r6*r2)*(r5*r3-r6*r2)+(r6*r1-r4*r3)*(r6*r1-r4*r3)+(r4*r2-r5*r1)*  
(r4*r2-r5*r1));
```

```
    xn[i]=(r5*r3-r6*r2)/r;
```

```
    yn[i]=(r6*r1-r4*r3)/r;
```

```
    zn[i]=(r4*r2-r5*r1)/r;
```

```
t1=px[mtj[i][3]]-px[mtj[i][1]];埃及尼羅河之旅
```

```
t2=py[mtj[i][3]]-py[mtj[i][1]];
```

```
t3=pz[mtj[i][3]]-pz[mtj[i][1]];
```

```
t4=px[mtj[i][4]]-px[mtj[i][1]];
```

```
t5=py[mtj[i][4]]-py[mtj[i][1]];
```

```
t6=pz[mtj[i][4]]-pz[mtj[i][1]];
```

```
r=.5*Math.sqrt((t2*t3-t3*r2)*(t2*t3-t3*r2)+(t3*r1-t1*r3)*(t3*r1-t1*r3)+(t1*r2-t2*r  
1)*(t1*r2-t2*r1));
```

```
t=.5*Math.sqrt((r2*t6-r3*t5)*(r2*t6-r3*t5)+(r3*t4-r1*t6)*(r3*t4-r1*t6)+(r1*t5-r2*t  
4)*(r1*t5-r2*t4));
```

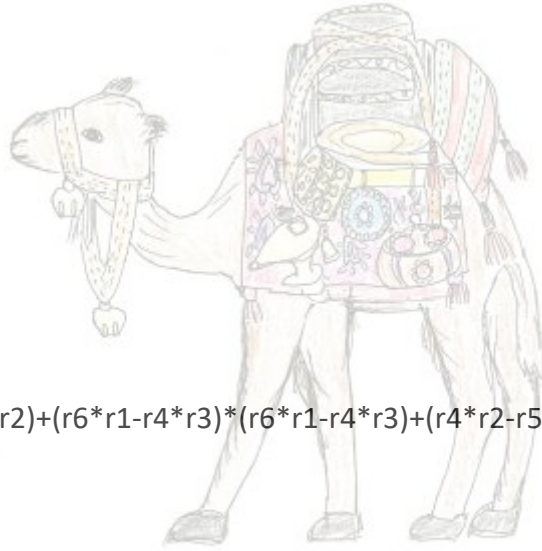
```
    area[i]=r+t;
```

```
}// normal
```

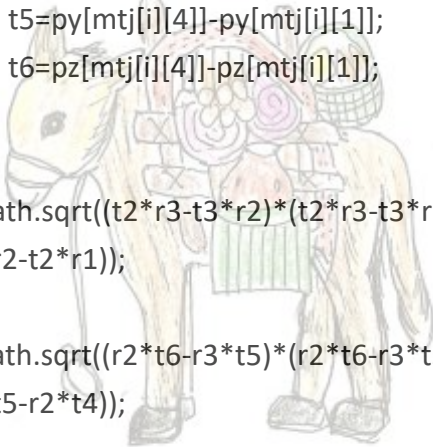
```
public void seki(double [][]a,double [][]b,int m,int na,int nk,int nb){
```

```
    int i,j,k;
```

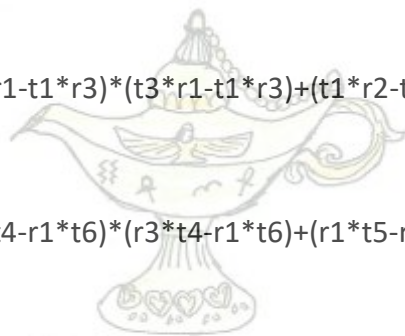
```
    double r;
```



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```
double []c=new double[m];
```

```
for(i=1;i<=na;i++){ for(k=1;k<=nk;k++){c[k]=a[i][k];}
for(j=1;j<=nb;j++){ r=0; for(k=1;k<=nk;k++){r=r+c[k]*b[k][j];}
a[i][j]=r;}}
```

```
//seki
```

```
public void minvs(double [][]a,int n0,int n,double eps){ // 只要設定 n0 與外部的值
相等即可,n<n0
```

```
int [] x=new int[n0];
```

```
int l,m,i,j,k;
```

```
double povit,absa,tmp,w;
```

```
for(i=1;i<=n;i++){x[i]=i;}
```

```
for(k=1;k<=n;k++){
```

```
    m=k;
```

```
    w=0.0;
```

```
    for(i=k;i<=n;i++){
```

```
        absa=Math.abs(a[i][k]);
```

```
        if(absa>w) {w=absa; m=i;}
```

```
    }
```

```
    if(m!=k) {
```

```
        l=x[m];
```

```
        x[m]=x[k];
```

```
        x[k]=l;
```

```
        for(j=1;j<=n;j++){
```

```
            w=a[k][j];
```

```
            a[k][j]=a[m][j];
```

```
            a[m][j]=w;}
```

```
    }
```

```
while(Math.abs(a[k][k])>=eps) {
```

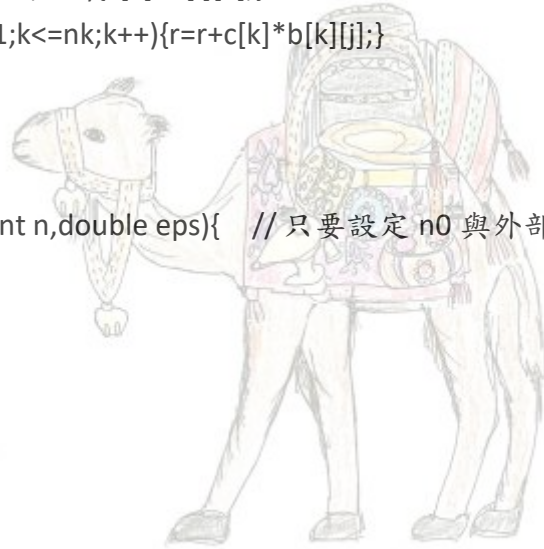
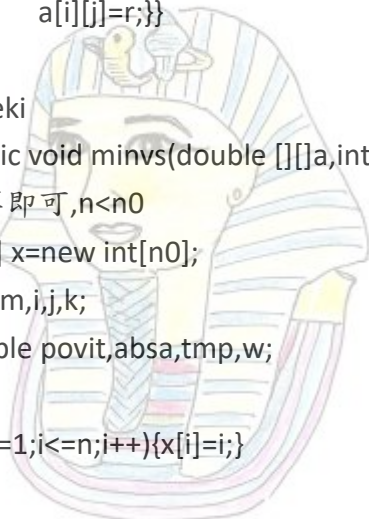
```
    povit=1.0/a[k][k];
```

```
    for(j=1;j<=n;j++){a[k][j]=a[k][j]*povit;}
```

```
    for(i=1;i<=n;i++){
```

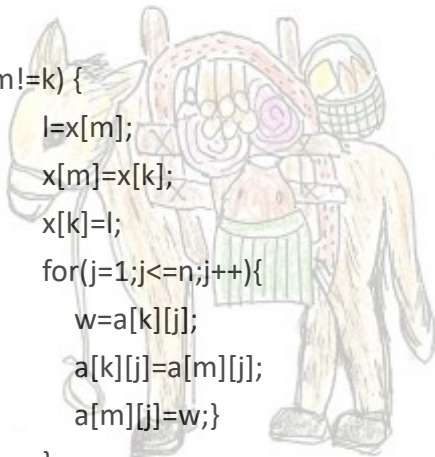
```
        tmp=-a[i][k];
```

```
        if((i!=k)&&(tmp!=0.0)){for(j=1;j<=n;j++){a[i][j]=a[i][j]+a[k][j]*tmp;}} }
```



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```

        a[i][k]=povit*tmp;}    //i
        a[k][k]=povit;
    } //while
} //k

for(i=1;i<=n;i++){
    while(x[i]!=i){
        k=x[i];
        for(j=1;j<=n;j++){
            w=a[j][i];
            a[j][i]=a[j][k];
            a[j][k]=w;}

        l=x[i];
        x[i]=x[k];
        x[k]=l;
    } //while
} //i
} //minvs

```



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```

} //all

```



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