COMPUTATIONAL PHYSICS (SSP2122)

Electrostatic potential

by

Abd. Khamim Ismail

Mohd Khalid Kasmin

1. **Calculation of electrostatic potential for a group of point charges**

You will learn about
- mesh method
  a) using a for() loop inside another for() loop
     to generate ordered pair (x,y) points in a mesh on x-y plane
  b) calculate physical value, in this case, V(x,y) for
     every point (x,y) generated
- saving calculated values into a file
  a) making a sequential text file
  b) saving in a format that gnuplot can understand
     for making a surface plot
- use gnuplot to visualize potential surface
  a) making a surface plot from data points in a text file
  b) making contour plot to visualize equipotential lines
  c) changing the z-axis range to zoom in or zoom out on the surface
  d) labelling the plot
  e) save as an image; the potential surface & the contour plot
  f) save as an eps file; the potential surface & the contour plot
- including an eps file into a document

2. **Calculation of electrostatic field for a group of point charges.**

You will learn again
- using mesh method to generate ordered pair (x,y) points
  in a mesh on x-y plane

You will also learn how to
- calculate vector field values, in this case, E(x,y) for every
  generated (x,y) mesh point
- save the calculated vector points into a text file
  in a format understood by gnuplot
- make a vector field plot using gnuplot

Source code:

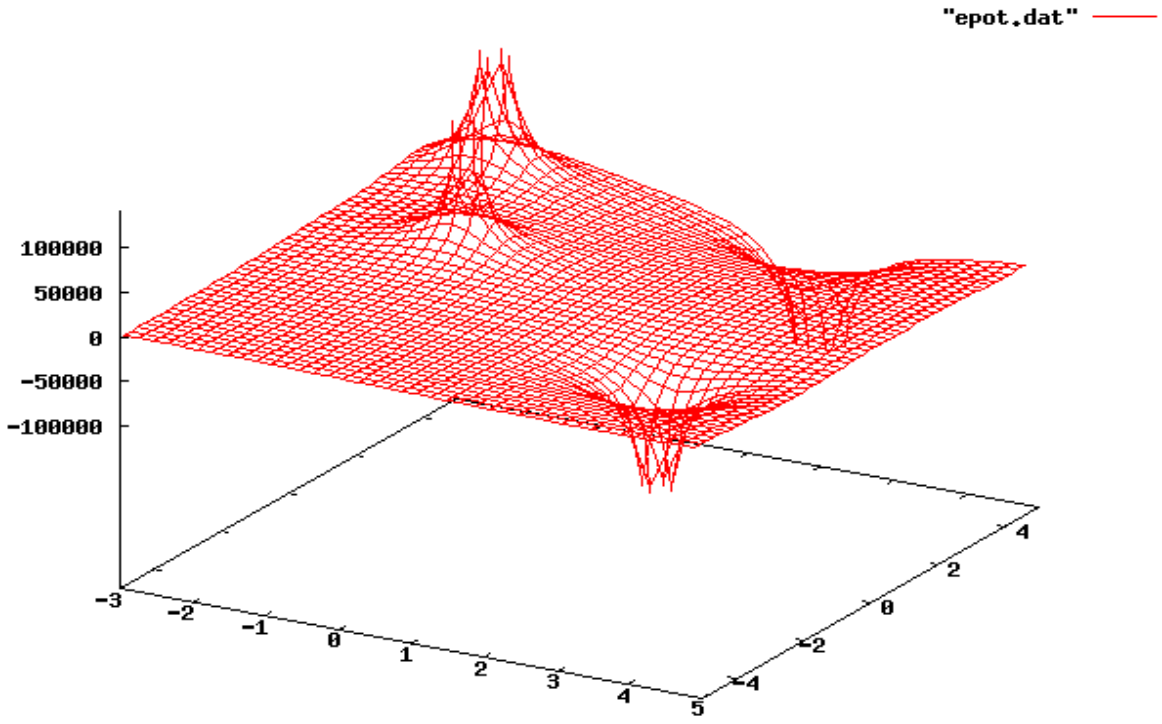
```
import static java.lang.Math.*;
public class estatpot01b
 {    public static void main(String[] args)
    {
       double[] q  = new double[100];
       double[] xq = new double[100];
       double[] yq = new double[100];
       double V, r, rx, ry, k, x, y;
       int    i, n;

       q[1] = 2.0e-6;  xq[1] = -1.0;  yq[1] = 1.0;
       q[2] =-3.0e-6;  xq[2] =  3.0;  yq[2] =-2.0;
       q[3] = 3.0e-6;  xq[3] = -2.0;  yq[3] = 4.0;
       q[4] =-5.0e-6;  xq[4] =  2.0;  yq[4] = 5.0;

       k = 9e9;
       n = 4;
```

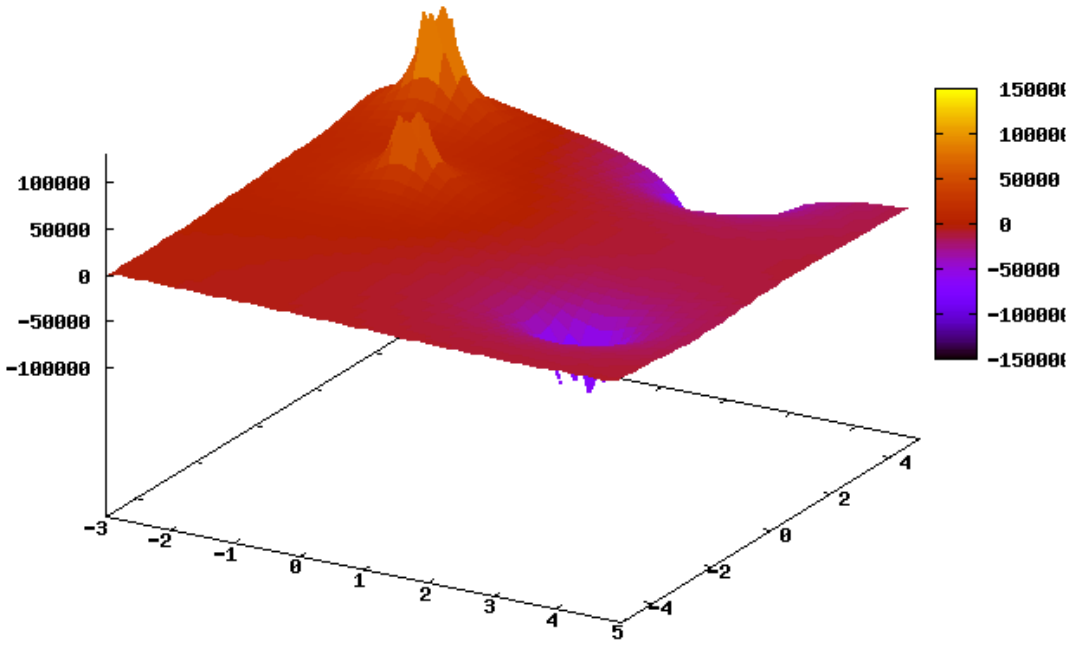
```
        for (x=-5; x<=5; x = x+0.2){
           for (y=5; y>=-5; y = y-0.2){
              V = 0.0;
              for(i=1; i<=n; i++)
              {
                 rx = x - xq[i];
                 ry = y - yq[i];
                 r  = sqrt(rx*rx+ry*ry);
                 if (r<1e-6) {
                    if (q[i]<0) V = -1.0; else V = 1.0;
                    break;
                 }
                 V  = V + q[i]/r;
              }
              V = k*V;
              System.out.printf("%f %f %f\n", x, y, V);
           }
           System.out.printf("\n");
        }
     }
  }
```

How to do surface plot using Gnuplot

```
To do a surface plot:
gnuplot> splot "epot.dat" with line
To zoom in and zoom out 'z' axis:
gnuplot> set zrange [-20000:20000]
To convert the graph into image:
gnuplot> set term png
Terminal type set to 'png'
Options are 'small color picsize 640 480 '
Then type:
gnuplot> set output "epot.png"
Again, do splot as follow:
gnuplot> splot "epot.dat" with line
Now the graph is saved into a file in .png format named as "epot.png"
To go back into terminal ouput:
gnuplot> set term x11
To set to countor plot
gnuplot> set pm3d
To remove countor mesh
gnuplot> unset surf
```

Gnuplot


"epot.dat"
100000
50000
0
-50000
-100000
-3
-2
-1
0
1
2
3
4
5
-4
-2
0
2
4


100000
50000
0
-50000
-100000
-3
-2
-1
0
1
2
3
4
5
-4
-2
0
2
4
150000
100000
50000
0
-50000
-100000
-150000