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Physics 40: Laboratory Eleven

Tuesday, May 5, 2020

## Today's Goals:

A random number test; Random numbers give a famous constant; Solving Laplace's Equation, part 1.

[0] To re-emphasize: The function RAND that you have been using generates 'random numbers' R which are equally likely to lie anywhere in the interval 0 < R < 1 (and no where else).

**[HW6-1]** Write a code that generates N = 10000 pairs of random numbers. Call the first member of each pair x and the second member y, and plot the pair x, y as points in the x-y plane. What do you expect to happen?

<u>Historical Note</u>: A defect in an early IBM random number generator was discovered by considering random numbers as points  $(x_1, x_2, \dots, x_m)$  in an *m*-dimensional space. See:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC285899/

In this problem you are studying the case m = 2.

**[HW6-2]** Write a code that generates N pairs of random numbers. Call the first member of each pair x and the second member y. Count how many of the N pairs obey  $x^2 + y^2 < 1$ . Call that number M, and have your code print out M/N.

What do you get for M/N when  $N = 10^2$ ? How about  $N = 10^4$ ,  $N = 10^6$  and  $N = 10^8$ ? Explain your result.

<u>Hint</u>: It might be useful to multiply the value you get for M/N by four.

<u>Warning</u>: Be careful how you define N and M. If you have variables N, M that are integers and compute N/M the computer will give you an *integer* which is the number of times Mgoes into N. Thus if N = 5 and M = 3 then N/M = 5/3 = 1. Similarly if N = 13 and M = 2 then N/M = 13/2 = 6. Finally, if N = 1 and M = 2 then N/M = 1/2 = 0. If you want 13/2 = 6.5 you need to tell the computer 13 is a double (or float) by declaring it as a double (or float). This is an important point to remember in coding. If you ever write a line of C code like y = (1/2) \* x; the computer will set y = 0 because it will compute 1/2 = 0before multiplying by x.

[1] Discussion of discretization of Laplace Equation. Similarities and differences with diffusion equation. Iterate to find solution- iteration step does *not* correspond to 'real time'.

[2] The following code computes the potential V[x][y] inside a box 0 < x < 3; 0 < y < 2 given the potential on the bottom (0 < x < 3; y = 0); on the left side (x = 0; 0 < y < 2); and on the right side (x = 3; 0 < y < 2) is V = 0. On the top (0 < x < 3; y = 2) is V = 8.

```
#include <stdio.h>
#include <math.h>
int main(void)
{
    FILE * fileout;
    int ix,iy,it,Nt;
    double newV[31][21],V[31][21],x,dx,y,dy;
    fileout=fopen("buckbeak.dat","w");
    printf("\nEnter number of iterations ");
    scanf("%d",&Nt);
    dx=0.10;
    dy=0.10;
    for (iy=0; iy<21; iy=iy+1)</pre>
    Ł
         for (ix=0; ix<31; ix=ix+1)</pre>
         {
             V[ix][iy]=0.0;
         }
    }
    iy=20;
    for (ix=0; ix<31; ix=ix+1)</pre>
    {
         V[ix][iy]=8.0;
    }
    for (it=0; it<Nt; it=it+1)</pre>
    Ł
        for (iy=1; iy<20; iy=iy+1)</pre>
         {
             for (ix=1; ix<30; ix=ix+1)</pre>
             ſ
                 newV[ix][iy]=0.25*(V[ix+1][iy]+ V[ix-1][iy]+V[ix][iy+1]+V[ix][iy-1]);
             7
        }
        for (iy=1; iy<20; iy=iy+1)</pre>
         {
             for (ix=1; ix<30; ix=ix+1)</pre>
             {
                 V[ix][iy]=newV[ix][iy];
             7
        }
    }
    for (iy=0; iy<21; iy=iy+1)</pre>
    {
        y=dy*iy;
        for (ix=0; ix<31; ix=ix+1)</pre>
        {
             x=dx*ix;
             fprintf(fileout,"\n %8.41f %8.41f %8.41f",x,y,V[ix][iy]);
         }
         fprintf(fileout,"\n");
    3
    printf("\n V at box center %12.61f",V[15][10]);
    fclose(fileout);
    printf("\n");
    return 0;
}
```

**[HW6-3]** Answer the following questions: In what array elements are the values of the potential on the boundaries stored?

Why do the ix loops go to 30 or 31 while the iy loops go to 20 or 21? Why do some of the ix loops go to 31 and others to 30?

**[HW6-4]** What values do you get for the potential at the center of the box for a number of iterations equal to 10, 20, 50, 100, 200, 500, 1000, 5000?