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#include <math.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

int main() {

    FILE *filename1,*filename2,*filename3,*filename4;
    char file1[150],file2[150],file3[150],file4[150];
    int N_time = 10001;
    int N_space = 1001;
    int i = 0, j = 0;

    //float x0 = -10.0, x1 = 10.0;
    float x0 = 0.0, x1 = 100.0;
    double *r, *u, *E,*E0 ;

    double dx = (x1 - x0) / (N_space - 1.);    // Step in x.
    double dt = 0.1 * dx * dx;                // Time step.
    double t= 0.0;

    u = new double[N_space];
    r = new double[N_space]; //values of u from previous time step
    E = new double[N_time];
    E0 = new double[N_time];

    // Initial condition.
    for (i = 0; i < N_space; i++) {
        u[i] = 1.0;
    }

    // Finite difference method
    for (j = 1; j < N_time; j++) {

        for(i=0; i < N_space; i++){
            r[i] = u[i]; //store the previous u information
        }

        // Solve for u[1] in new time step
        u[1]=r[1] + dt/(dx*dx) * (r[2]-2*r[1]+r[0]);

        // Go back for the new u[0] (Based on b.c.)
        u[0]=u[1]/(1+dx);

        // Solve for other u's
        for(i=2; i<N_space-1; i++){
            u[i]=r[i] + dt/(dx*dx) * (r[i+1]-2*r[i]+r[i-1]);
        }

        t+=dt;

        // Energy conservation
        for (i=0; i < N_space; i++){
            E[j] += u[i]*dx ;
        }
        E0[j] = u[0]; //RHS of integral
    }
}

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// Print out the information at a specified timestep
    if (j == 100) {
        strcpy (file1, "/home/quantum-monkey/workspace/CPAcodes/ps9/data/
p2data1.dat");
        filename1 = fopen (file1, "w");
        for (i = 0; i < N_space; i++) {
            fprintf(filename1,"%d\t%d\t%f\t%f\n", j, i, x0 + i * dx, u[i])
            ;
        }
        fclose (filename1);
    }

    if (j == 5000) {
        strcpy (file2, "/home/quantum-monkey/workspace/CPAcodes/ps9/data/
p2data2.dat");
        filename2 = fopen (file2, "w");
        for (i = 0; i < N_space; i++) {
            fprintf(filename2,"%d\t%d\t%f\t%f\n", j, i, x0 + i * dx, u[i])
            ;
        }
        fclose (filename2);
    }

    if (j == 7000) {
        strcpy (file3, "/home/quantum-monkey/workspace/CPAcodes/ps9/data/
p2data3.dat");
        filename3 = fopen (file3, "w");
        for (i = 0; i < N_space; i++) {
            fprintf(filename3,"%d\t%d\t%f\t%f\n", j, i, x0 + i * dx, u[i])
            ;
        }
        fclose (filename3);
    }
}

//Print out energy conservation
strcpy (file4, "/home/quantum-monkey/workspace/CPAcodes/ps9/data/
p2energy.dat");
filename4 = fopen (file4, "w");
for ( j = 1; j < N_time; j++) {
    if (j%50 ==0)
        fprintf(filename4,"%d\t%f\t%f\n",j, j*dt, (E[j]-E[j-1]+E0[j]*dt)/(E[j]
-E[j-1]));
}

fclose(filename4);

free(u);
free(r);
free(E);
free(E0);

return 0;
}

```