# MA3237 2110: Project #1

Due on Thusday, 20 Feb 2014

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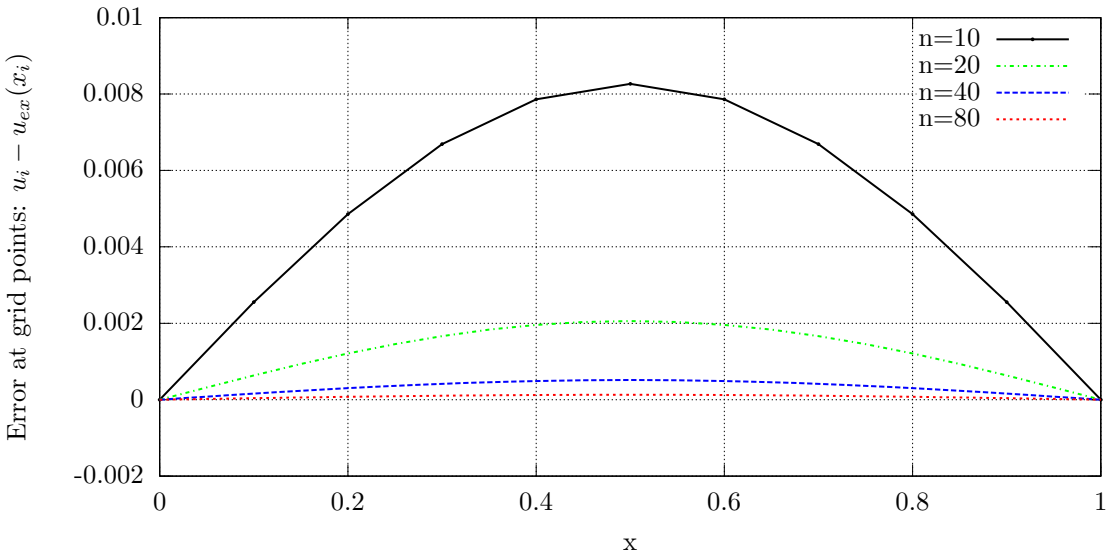
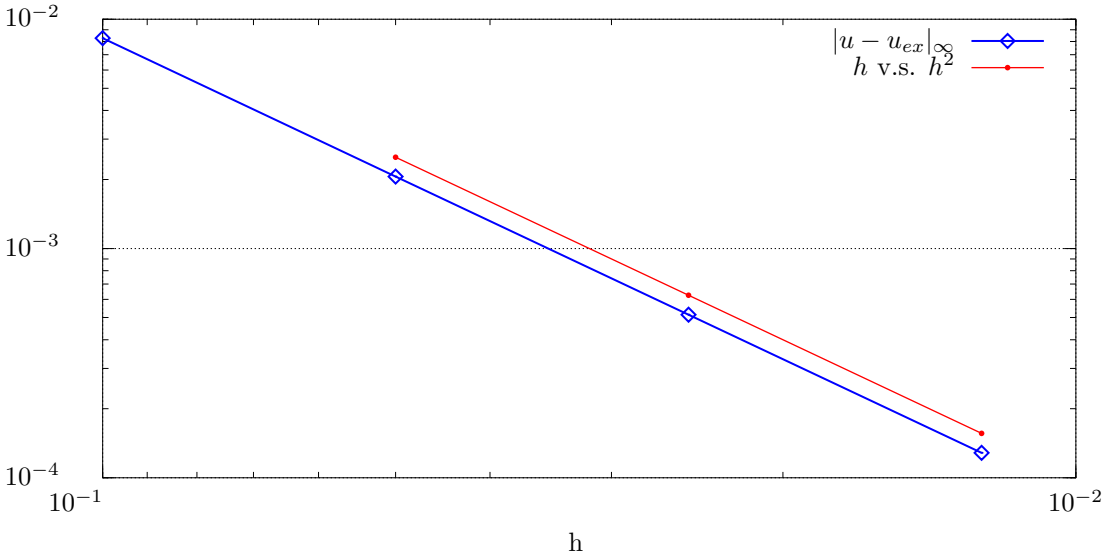
## Matlab Code

```
clear; close all;
function f = F(x)
        f=pi^2*sin(pi*x);
end % function
%-----------------------------------
function u = U(x)
        u=sin(pi*x);
end % function
%-----------------------------------
function upp = A(u)
        m=size(u,1);
        DD=sparse(1:m,1:m,2,m,m)+sparse(2:m,1:m-1,-1,m,m)+sparse(1:m-1,2:m,-1,m,m);
        upp = DD*u;
end % function
%-----------------------------------
function x_bar=rgd_solve(A,f,h)
        m=size(f,1);
        DD=sparse(1:m,1:m,2,m,m)+sparse(2:m,1:m-1,-1,m,m)+sparse(1:m-1,2:m,-1,m,m);
        x_bar = DD\(f*h^2);
end % function
%-----------------------------------------------------
function x_bar=cgd_solve(A,f,h,iter_max = 100)
        b = f*h^2;
        k = 0;
        x = zeros(size(b));
        r = b - A(x);
        p = r;

        while(k < iter_max && max(abs(r))>=0.000000001)
                k = k + 1
                a = r'*p./(p'*(A(p)));
                x = x + a*p;
                r_old = r;
                r = r - a*(A(p));
                b = r'*r./(r_old'*r_old);
                p = r + b*p;
        end %while
        x_bar = x;

end % function
%-----------------------------------------------------
N=[10,20,40,80];
drawStr={'r','b-.','g--','y:'};
maxerr = zeros(length(N),1);

error_plot = figure(1);
hold on;
```

```
grid on;
legendStr=cell(1,length(N));
I = 1;
for n = N
        h = 1/n;
        mesh = linspace(0,1,n+1)';
    Au = F(mesh);

        x_bar = [0;cgd_solve(@A, Au(2:end-1),h);0];
        err = x_bar - U(mesh);
    plot(mesh, err, drawStr(I),'LineWidth',1,'MarkerSize',2)
    maxerr(I) = max(abs(err));
        clear("err")
        legendStr{I}=['n=',num2str(n)];
        I = I+1;
end

legend(legendStr);
xlabel('x');
ylabel('Error at grid points: u_i-u_{ex}(x_i)')
print(error_plot,'error_plot.tex','-S900,450','-dtex')
hold off;

error_n_plot = figure(2);
loglog(1./N,maxerr,'d-b','LineWidth',1,'MarkerSize',5)
set(gca,'XDir','reverse');
grid on;
hold on;
loglog(1./N,(1./N).^2,'.-r','LineWidth',1);
legend('|u-u_{ex}|_{\infty}','h v.s. h^2');
xlabel('h');
print(error_n_plot,'error_n_plot.tex','-S900,450','-dtex')
hold off;
```


0.01
0.008
0.006
0.004
0.002
0
-0.002
0
0.2
0.4
0.6
0.8
1
x
Error at grid points: $u_i - u_{ex}(x_i)$
n=10
n=20
n=40
n=80


$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-1}$
$10^{-2}$
h
$|u - u_{ex}|_\infty$
$h$ v.s. $h^2$