

1 /\* Math/CS 466/666 Midterm Solutions

Problem 1(iv). Consider the approximation

$$f''(x) \approx \frac{f(x+h) - 2f(x) + f(x-h)}{h^2}.$$

Let  $f(x) = \sin(x^2)$ . Write or modify a computer program to create a table showing the approximation and the errors in the approximation when  $x = 2$  and  $h = 2^{-n}$  for  $n = 0, 1, \dots, 30$ . \*/

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10
11 #include <stdio.h>
12 #include <math.h>
13
14 double f(double x){
15     return sin(x*x);
16 }
17 double ddf(double x){
18 /* Always set this to  $f''(x)$  where  $f(x)$  is defined above. Since  $f'(x) = 2x \cos(x^2)$  then
    the exact second derivative is  $f''(x) = 2 \cos(x^2) - 4x^2 \sin(x^2)$ . */
21     double xx=x*x;
22     return 2*cos(xx)-4*xx*sin(xx);
23 }
24 double addf(double x,double h){
25     return (f(x+h)-2*f(x)+f(x-h))/(h*h);
26 }
27
28 int main(){
29     printf("Math/CS 466/666 Midterm\nProblem 1(iv)\n\n");
30     double h=1,x=2;
31     printf("%3s %22s %22s %22s\n","n","h","approximation","error");
32     for(int n=0;n<=30;n++,h/=2){
33         printf("%3d %22.14e %22.14e %22.14e\n",
34             n,h,addf(x,h),addf(x,h)-ddf(x));
35     }
36     return 0;
37 }

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