# Lab 07
# MATH 3180: Numerical Analysis

Jackson Cole

October 18, 2018

# Contents

October 5, 2018

# CSCI/MATH 3180
# Lab Assignments #6 and #7

Construct the Newton form of the interpolating polynomial of degree 8 for the function $f(x) = \frac{1}{(x^2+1)}$ using the data points at $x$ = -8,-6, -4, -2, 0, 2, 4, 6, 8.

**Lab #6. Use Maple to do the following task.**

1. Create the nine data points.
2. Create the divided difference table using the data set.
3. Create the Newton form of the interpolating polynomial of degree 8, $P_8(x)$ using the data set.
4. Evaluate f(x), $P_8(x)$, and | f(x)-$P_8(x)$| for the 17 points at x = -8,-7,-6, -5, -4, -3,-2, -1, 0, 1, 2, 3, 4, 5, 6,7,8.
5. Plot f(x) and $P_8(x)$

**<u>Submission:</u>** YourLastNameMaple6.mw

**Lab #7. Use Visual Studio 2015 to do the following task.**

1. Create a C++ console application project in Visual Studio 2015 and name your project **YourLastName7**.
2. Write a program that implements the Newton Interpolation discussed in class.
3. Write a separate function for each of the following. You may define and call additional functions.
   - Computation of divided differences
   - Evaluation of the interpolating polynomial
     Must use a nested form as discussed in class.
4. Your program must store divided differences in a single dimensional array.
5. All floating point arithmetic will be **double** precision.
6. Program input:
   Sequence of x values of data points
   Sequence of x values to evaluate P(x)
7. Program output
   - Divided differences at each iteration
   - Table containing f(x), P(x), |f(x) – P(x)| for the 17 data points.

**<u>Submission</u>**

1. Delete the following from your Visual Studio project folder.
   - *Debug* sub-folder
   - *Debug* sub-sub-folder under your project folder(second level down)
   - *sdf* file.
2. Save the following in a compressed (zipped) folder.
   **YourLastName7** -- *main project folder*
3. Submit the compressed folder to D2L.
4. **Confirm** your submission.
   - **Download** the zipped folder which you have submitted and **check the contents**.
   - Multiple submissions are allowed, but the last submission will be graded.

***NOTE: <u>LABS MUST BE YOUR ORIGINAL AND INDEPENDENT WORK.</u>***

# LABs #6 and #7 EVALUATION RUBRIC

<table>
<tr><td colspan="3">Lab 6:  Maple worksheet</td></tr>
<tr><td colspan="2">✓ Maple worksheet meets the requirements described above.</td><td>__/10</td></tr>
<tr><td colspan="3">Lab 7: Programming Project</td></tr>
<tr><td rowspan="2">1</td><td colspan="2">Solve the assigned problem using methods described in program description.</td></tr>
<tr><td>The program input meets the requirements. (1 pt)<br>➢ Sequence of x values of data points<br>➢ Sequence of x values to evaluate P(x)<br>The program implements the following separate functions. (1 pt)<br>➢ Computation of divided differences<br>➢ Evaluation of the interpolating polynomial using a nested form<br>The program stores divided differences in a single dimensional array. (1 pt)<br>Program output meets the requirements. (2 pts)<br>• Divided differences at each iteration<br>• Table containing f(x), P(x), |f(x) – P(x)| for the 17 data points.</td><td>__/5</td></tr>
<tr><td>2</td><td>Compilation/Execution<br>➢ Compile without errors when tested in the CSCI computer lab.<br>➢ Execute without crashing when tested in the CSCI computer lab.</td><td>__/1</td></tr>
<tr><td>3</td><td>Produce correct answers.<br>➢ Divided differences at each iteration<br>➢ Table containing f(x), P(x), |f(x) – P(x)| for the 17 data points</td><td>__/2</td></tr>
<tr><td>4</td><td>The program output well formatted and properly labeled and identified.</td><td>__/1</td></tr>
<tr><td>5</td><td>Main Comment Block includes the following.<br>file name     due date     author     course #<br>program description     input     output</td><td>__/0.5</td></tr>
<tr><td>6</td><td>Documentation, indentation, and white space usage<br>✓ Meaning variable names are used and they are briefly described.<br>✓ Each section of statements in the program is well documented.<br>✓ Proper INDENTATION is used to make the program easier to read.<br>✓ WHITE SPACES are used in appropriate places for readability.</td><td>__/0.5</td></tr>
<tr><td>7</td><td>Contents of zipped folder<br>✓ Zip folder contains the two items described above.<br>✓ The project folder does NOT contain the following.<br>❖ Debug sub-folder<br>❖ Debug sub-sub-folder<br>❖ .sdf file</td><td></td></tr>
<tr><td></td><td>TOTAL</td><td>__/10</td></tr>
</table>

## 0.1 Description of Experiment

In this experiment, we were tasked with constructing the Newtonian form of the interpolating polynomial for the function

$$f(x) = \frac{1}{x^2+1}.$$

We then proceed to evaluating our constructed interpolating polynomial at several data points within the bounds of the given data points (interpolating). The program input and output are given below, where the program input is assumed to be of the form given (i.e. number of values, followed by space separated values, followed by number of values, followed by space separated values).

## 0.2 Program Input

```
9
-8 -6 -4 -2 0 2 4 6 8
17
-8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8
```

## 0.3 Program Output

```
How many data points?  9
Enter x values separated by spaces: -8 -6 -4 -2 0 2 4 6 8
How many test values?  17
Enter all x values separated by spaces: -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8

----------------------------------------
Divided Differences
----------------------------------------
Iteration: 0
---------------
   0.0153846154
   0.0270270270
   0.0588235294
   0.2000000000
   1.0000000000
   0.2000000000
   0.0588235294
   0.0270270270
   0.0153846154

Iteration: 1
---------------
   0.0153846154
   0.0058212058
   0.0158982512
   0.0705882353
   0.4000000000
  -0.4000000000
  -0.0705882353
  -0.0158982512
  -0.0058212058

Iteration: 2
---------------
   0.0153846154
```

```
   0.0058212058
   0.0025192613
   0.0136724960
   0.0823529412
  -0.2000000000
   0.0823529412
   0.0136724960
   0.0025192613

Iteration: 3
---------------
   0.0153846154
   0.0058212058
   0.0025192613
   0.0018588724
   0.0114467409
  -0.0470588235
   0.0470588235
  -0.0114467409
  -0.0018588724

Iteration: 4
---------------
   0.0153846154
   0.0058212058
   0.0025192613
   0.0018588724
   0.0011984836
  -0.0073131955
   0.0117647059
  -0.0073131955
   0.0011984836

Iteration: 5
---------------
   0.0153846154
   0.0058212058
   0.0025192613
   0.0018588724
   0.0011984836
  -0.0008511679
   0.0019077901
  -0.0019077901
   0.0008511679

Iteration: 6
---------------
   0.0153846154
   0.0058212058
   0.0025192613
   0.0018588724
   0.0011984836
  -0.0008511679
   0.0002299132
  -0.0003179650
   0.0002299132
```

```
Iteration: 7
---------------
   0.0153846154
   0.0058212058
   0.0025192613
   0.0018588724
   0.0011984836
  -0.0008511679
   0.0002299132
  -0.0000391342
   0.0000391342

Iteration: 8
---------------
   0.0153846154
   0.0058212058
   0.0025192613
   0.0018588724
   0.0011984836
  -0.0008511679
   0.0002299132
  -0.0000391342
   0.0000048918
```

| i | x | f(x) | P8(x) | \|f(x) - P8(x)\| |
|---|---|---|---|---|
| 0 | -8.000 | 0.0153846154 | 0.0153846154 | 0.0000000000 |
| 1 | -7.000 | 0.0200000000 | -1.3682034976 | 1.3882034976 |
| 2 | -6.000 | 0.0270270270 | 0.0270270270 | 0.0000000000 |
| 3 | -5.000 | 0.0384615385 | 0.4198361257 | 0.3813745873 |
| 4 | -4.000 | 0.0588235294 | 0.0588235294 | 0.0000000000 |
| 5 | -3.000 | 0.1000000000 | -0.1288247524 | 0.2288247524 |
| 6 | -2.000 | 0.2000000000 | 0.2000000000 | 0.0000000000 |
| 7 | -1.000 | 0.5000000000 | 0.7426929192 | 0.2426929192 |
| 8 | 0.000 | 1.0000000000 | 1.0000000000 | 0.0000000000 |
| 9 | 1.000 | 0.5000000000 | 0.7426929192 | 0.2426929192 |
| 10 | 2.000 | 0.2000000000 | 0.2000000000 | 0.0000000000 |
| 11 | 3.000 | 0.1000000000 | -0.1288247524 | 0.2288247524 |
| 12 | 4.000 | 0.0588235294 | 0.0588235294 | 0.0000000000 |
| 13 | 5.000 | 0.0384615385 | 0.4198361257 | 0.3813745873 |
| 14 | 6.000 | 0.0270270270 | 0.0270270270 | 0.0000000000 |
| 15 | 7.000 | 0.0200000000 | -1.3682034976 | 1.3882034976 |
| 16 | 8.000 | 0.0153846154 | 0.0153846154 | 0.0000000000 |

## 0.4 Conclusion/Findings

In this experiment, this method provides essentially the exact same results as the Maple implementation we did in Lab 06. We see that the error of our interpolating polynomial is 0 when evaluated at values of $x$ from which the polynomial was constructed, but is greater when actually interpolating values using our constructed polynomial.