CSE 4746: Numerical Methods Lab
Assignment 2

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Problem 1: Difference Table

Problem Statement

The following values of $f(x)$ are given:

x	1	2	3	4	5
$y = f(x)$	1	8	27	64	125

Write a program to find the difference table for the above values.

Solution

View on GitHub

```
#include <bits/stdc++.h>
using namespace std;

int main() {
    int n = 5;
    int x[] = {1, 2, 3, 4, 5};
    int y[n][n];
    y[0][0] = 1; y[1][0] = 8; y[2][0] = 27; y[3][0] = 64; y[4][0] = 125;

    for (int i = 1; i < n; i++) {
        for (int j = 0; j < n - i; j++)
            y[j][i] = y[j + 1][i - 1] - y[j][i - 1];
    }

    for (int i = 0; i < n; i++) {
        cout << setw(4) << x[i] << "\t";
        for (int j = 0; j < n - i; j++) {
            cout << setw(4) << y[i][j] << "\t";
        }
        cout << endl;
    }
    return 0;
}
```

Output

```
1      1      7     12      6      0
2      8     19     18      6      0
3     27     37     24      0      0
4     64     61      0      0      0
5    125      0      0      0      0
```

Problem 2: Newton's Forward Interpolation

Problem Statement

Using the same data as Problem 1, write a program to find the value of y when $x = 1.7$ using Newton's forward interpolation formula.

Solution

View on GitHub

```cpp
#include <bits/stdc++.h>
using namespace std;

float u_cal(float u, int n) {
    float temp = u;
    for (int i = 1; i < n; i++)
        temp = temp * (u - i);
    return temp;
}

int fact(int n) {
    int f = 1;
    for (int i = 2; i <= n; i++) f *= i;
    return f;
}

int main() {
    int n = 5;
    int x[] = {1, 2, 3, 4, 5};
    int y[n][n];
    y[0][0] = 1; y[1][0] = 8; y[2][0] = 27; y[3][0] = 64; y[4][0] = 125;

    for (int i = 1; i < n; i++) {
        for (int j = 0; j < n - i; j++)
            y[j][i] = y[j + 1][i - 1] - y[j][i - 1];
    }

    float xi = 1.7;
    float sum = y[0][0];
    float u = (xi - x[0]) / (x[1] - x[0]);
    for (int i = 1; i < n; i++) {
        sum = sum + (u_cal(u, i) * y[0][i]) / fact(i);
    }
    cout << "\n Value at " << xi << " is " << sum << endl;
    return 0;
}
```

Output

```
Value at 1.7 is 4.913
```

Problem 3: Newton's Backward Interpolation

Problem Statement

Using the same data, write a program to find the value of y when $x = 4.7$ using Newton's backward interpolation formula.

Solution

View on GitHub

```
#include <bits/stdc++.h>
using namespace std;

float u_cal(float u, int n) {
    float temp = u;
    for (int i = 1; i < n; i++)
        temp = temp * (u + i);
    return temp;
}

int fact(int n) {
    int f = 1;
    for (int i = 2; i <= n; i++) f *= i;
    return f;
}

int main() {
    int n = 5;
    int x[] = {1, 2, 3, 4, 5};
    int y[n][n];
    y[0][0] = 1; y[1][0] = 8; y[2][0] = 27; y[3][0] = 64; y[4][0] = 125;

    for (int i = 1; i < n; i++) {
        for (int j = n - 1; j >= i; j--) {
            y[j][i] = y[j][i - 1] - y[j - 1][i - 1];
        }
    }

    float xi = 4.7;
    float sum = y[n - 1][0];
    float u = (xi - x[n - 1]) / (x[1] - x[0]);
    for (int i = 1; i < n; i++) {
        sum = sum + (u_cal(u, i) * y[n - 1][i]) / fact(i);
    }
    cout << "\n Value at " << xi << " is " << sum << endl;
    return 0;
}
```

Output

```
Value at 4.7 is 103.823
```

Problem 4: Lagrange's Inverse Interpolation

Problem Statement

Using the same data, write a program to find the value of x for which $f(x) = 85$ using Lagrange's inverse interpolation formula.

Solution

View on GitHub

```
#include <bits/stdc++.h>
using namespace std;

int main() {
    int n = 5;
    int x[] = {1, 2, 3, 4, 5};
    int y[n] = {1, 8, 27, 64, 125};
    int yi = 85;
    float xi = 0;

    for (int i = 0; i < n; i++) {
        float up = 1, down = 1;
        for (int j = 0; j < n; j++) {
            if (i == j) continue;
            up *= (yi - y[j]);
            down *= (y[i] - y[j]);
        }
        xi += (up / down) * x[i];
    }
    cout << xi << endl;
    return 0;
}
```

Output

```
2.935
```

Problem 5: Newton's Divided Difference

Problem Statement

The following values of $f(x)$ are given:

x	1	3	4	6	10
$y = f(x)$	0	18	58	190	920

Write a program to:

1. Prepare the divided difference table
2. Find the value of y when $x = 2.7$ using Newton's divided difference formula

Solution

View on GitHub

```
#include <bits/stdc++.h>
using namespace std;

float proterm(int i, float xi, int x[]) {
    float pro = 1;
    for (int j = 0; j < i; j++) {
        pro = pro * (xi - x[j]);
    }
    return pro;
}

void dividedDiffTable(int x[], float y[][10], int n) {
    for (int i = 1; i < n; i++) {
        for (int j = 0; j < n - i; j++) {
            y[j][i] = (y[j][i - 1] - y[j + 1][i - 1]) / (x[j] - x[i + j]);
        }
    }
}

float applyFormula(float xi, int x[], float y[][10], int n) {
    float sum = y[0][0];
    for (int i = 1; i < n; i++) {
        sum = sum + (proterm(i, xi, x) * y[0][i]);
    }
    return sum;
}

void printDiffTable(float y[][10], int n) {
    for (int i = 0; i < n; i++) {
        for (int j = 0; j < n - i; j++) {
            cout << setprecision(4) << y[i][j] << "\t ";
        }
        cout << endl;
    }
}

int main() {
    int n = 5;
    float y[10][10];
    int x[] = {1, 3, 4, 6, 10};
    y[0][0] = 0; y[1][0] = 18; y[2][0] = 58; y[3][0] = 190; y[4][0] = 920;

    dividedDiffTable(x, y, n);
    printDiffTable(y, n);

    float xi = 2.7;
    float sum = applyFormula(xi, x, y, n);
    cout << "\nValue at " << xi << " is " << sum << endl;
    return 0;
}
```

Output

```
0        9        11       1.5      -0.06429
18        40        13.5        0.375
58        66        15.5
190        182.5
920

Value at 2.7 is 9.926
```

Conclusion

This lab assignment involved implementing various numerical interpolation methods including difference tables, Newton's forward and backward interpolation, Lagrange's inverse interpolation, and Newton's divided difference method. The programs successfully computed the required values for given data points.

All source code is available on GitHub:

- Problem 1 Solution
- Problem 2 Solution
- Problem 3 Solution
- Problem 4 Solution
- Problem 5 Solution